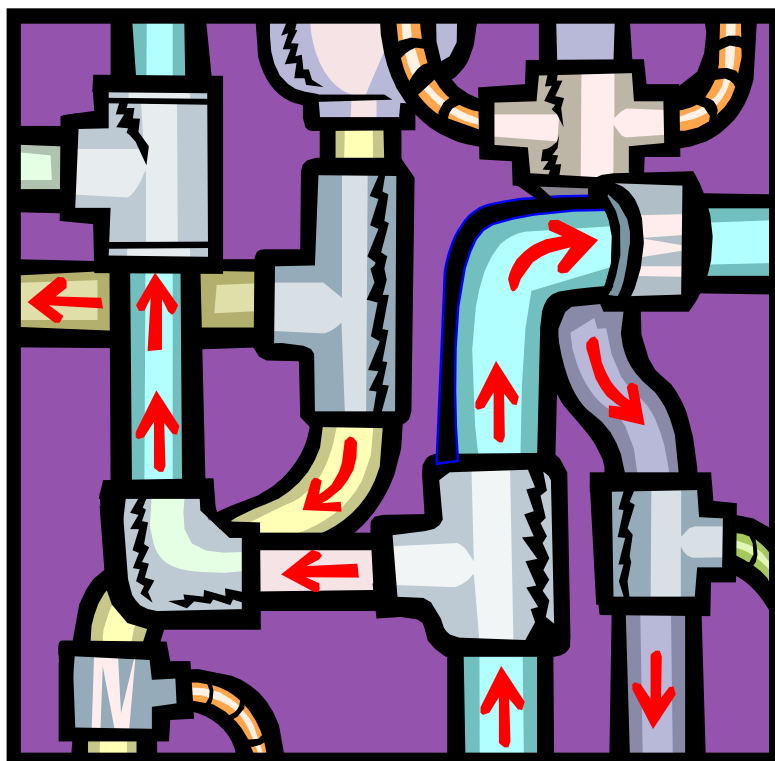


# Waterworks Operator Certification Program Guideline

June 2013



DOH 331-109 (Revised)

# Waterworks Operator Certification Program Guideline

June 2013



For more information or additional copies of this guideline contact:

Waterworks Operator Certification Program  
Office of Drinking Water  
Department of Health  
PO Box 47822  
Olympia, Washington 98504-7822  
360-236-3141  
Toll-free 800-525-2536

If you need this publication in an alternate format, call 800-525-0127. For TTY/TDD, call 800-833-6388.

# Table of Contents

Introduction .....	i
Contact Information.....	ii
Regional Office Technical Assistance .....	iv
<b>Section 1 Water Systems .....</b>	<b>1</b>
System Requirements .....	2
System Classification .....	4
Guidelines for use of ABC Purification Plant Criteria Worksheet .....	6
ABC Purification Plant Criteria Worksheet.....	10
System Temporary Operator Certification.....	12
System Certification Fees .....	13
System Compliance and Enforcement .....	14
<b>Section 2 Waterworks Operators .....</b>	<b>19</b>
Duties of the Operator(s) in Responsible Charge .....	16
Certified Operator Responsibilities .....	17
Contract Operator .....	18
Education and Experience Requirements .....	19
Substitutions for Education and Experience .....	22
Operator Certification Fees.....	24
Reciprocity with Other States .....	25
Application and Exam Process .....	26
Certification Renewal Process .....	28
Professional Growth .....	29
Revocation and Suspension .....	34
Relevancy Review and Appeal Procedure.....	35
<b>Section 3 Backflow Assembly Testers .....</b>	<b>20</b>
Backflow Assembly Tester Certification.....	37
Backflow Assembly Tester Certification Exam .....	38
Backflow Assembly Tester Professional Growth Requirement.....	40
Backflow Assembly Tester Professional Growth Exam.....	41
Backflow Assembly Tester Certification Renewal Process.....	43
Backflow Assembly Tester Revocation and Suspension .....	44
Backflow Assembly Tester Certification Written Exam Subject Areas .....	45
Backflow Assembly Tester Exam Reference Materials .....	46
Backflow Assembly Tester Professional Growth Exam Reference Materials .....	47
<b>Appendices .....</b>	<b>53</b>
Appendix A     Water Distribution Specialist (WDS) Exam Information .....	49
Appendix B     Water Distribution Manager (WDM) Exam Information .....	51
Appendix C     Water Distribution Specialist and Water Distribution Manager Exam Reference Materials .....	54
Appendix D     Basic Treatment Operator (BTO) Exam Information .....	56
Appendix E     Water Treatment Plant Operator (WTPO) Exam Information .....	57
Appendix F     Basic Treatment Operator and Water Treatment Operator Exam Reference Materials .....	60
Appendix G     Cross-Connection Control Specialist (CCS) Exam Information.....	62
Appendix H     Cross Connection Control Specialist (CCS) Exam Reference Materials .....	63
Appendix I     ABC Formula and Conversion Table for Water Treatment and Distribution Exams .....	64

# Introduction

---

<b>Mission Statement</b>	The mission of the Department of Health Office of Drinking Water is to protect the health of the people of Washington state by assuring safe and reliable drinking water.
<b>Certification Program</b>	<p>The Department of Health (DOH) administers the Waterworks Operator Certification Program in coordination with the Waterworks Operator Certification Advisory Committee (Committee). DOH is responsible for routine program activities. The program goal is to ensure safe, efficient, and effective operation of public water systems. The Committee advises DOH.</p> <p>Water systems must employ certified operators to carry out various operational functions. To become certified, operators must meet minimum education and experience requirements and pass an exam. In addition, certified operators must meet a professional growth requirement every three years to maintain their certification status.</p> <p>The program is self-sufficient. It charges fees for services it provides to water systems and operators. These services include evaluation of education and experience, professional growth requirements, career development, operator listings, and enforcement actions.</p>
<b>Legal Authority</b>	The Waterworks Operator Certification Program operates under authority of the Revised Code of Washington (RCW 70.119). More detailed and comprehensive program regulations are in Washington Administrative Code (WAC 246-292).
<b>Purpose of this Guideline</b>	The Waterworks Operator Certification Program Guideline helps water systems, waterworks operators, and backflow assembly testers meet program requirements. It complements the regulations by clarifying how water systems are classified, education and experience requirements for different operator classifications, procedures for renewing certifications, how to meet professional growth requirements, and so on.
<b>Guideline Applicability</b>	This document is for water system purveyors, waterworks operators, backflow assembly testers, and individuals who want information on the Waterworks Operator Certification Program in Washington state. It has three sections. Section 1 contains important information for water systems and explains how the Waterworks Operator Certification Program affects them. Section 2 provides information for waterworks operators about the certification process. Section 3 provides information for backflow assembly testers about the certification process. DOH also uses the guideline extensively in carrying out program administrative responsibilities.

## Contact Information

---

Please direct questions about the information in this **guideline**, or requests about the **Waterworks Operator Certification Program** to:

Waterworks Operator Certification Program  
Office of Drinking Water  
PO Box 47822  
Olympia, Washington 98504-7822  
Website:

<http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/RegulationandCompliance/WaterworksOperatorCertification.aspx>

### **Denise (Deni) Gray, Waterworks Operator Certification Lead**

Call 360-236-3140 or 800-525-2536, Ext. 3

- Certification Requirements for Large Group A Community Systems
- Certification Requirements for Filtered Systems
- Operator Education and Experience Requirements
- Relevancy Appeal Procedure
- General Certification Information

### **Judy Carter, Deputy Program Manager**

Call 360-236-3139 or 800-525-2536, Ext. 2

- Certification Requirements for Small Water Systems
- Operator Education and Experience Requirements
- Operator Renewals
- Cross Connection Control Certification
- General Certification Information

### **Willa Lawton, Certification Compliance Manager**

Call 360-236-3145 or 800-525-2536, Ext. 4

- Temporary Certification Information
- Contract Operator Requirements and Public Listing
- Certification Compliance
  - Bilateral Compliance Agreement (BCA)
  - Notice of Violation (NOV)
  - Departmental Order (DO)

### **Larry Granish**

Call 360-236-3141 or 800-525-2536, Ext. 1

- Exam
- Application Packets
- Operator Address Changes
- Operator Renewals
- Validation Cards

Please direct questions about the **Waterworks Professional Growth Program** and the **Backflow Assembly Tester Certification Program** to:

**Washington Certification Services**

Green River Community College

110 2<sup>nd</sup> Street SW Suite 135

Auburn, Washington 98001

Call 253-288-3357 or 877-780-2444

Website: <http://www.wacertservices.org>

**Peggy Barton, Director, Washington Certification Services**

- Waterworks Operator Professional Growth Program
- Waterworks Training Evaluation and CEU Assignment
- BAT Certification Program Administration and Exam Scheduling

**Rachel Neville, Backflow Assembly Tester Certification Program Manager**

- Backflow Assembly Tester Certification
- Backflow Assembly Tester Certification Renewal
- Backflow Assembly Tester Professional Growth Program

**Pamela Basquez, Washington Certification Services Support**

- Waterworks Operator Professional Growth Inquiries
- BAT Certification and Professional Growth Exam Applications

## Regional Office Technical Assistance

---

Drinking water system owners, operators and managers can get information by calling the Department of Health regional offices listed below from 8 a.m. to 5 p.m. Monday through Friday. For after-hours or weekend emergencies, call the toll-free hotline at (877) 481-4901.

Office of Drinking Water (ODW) staff is available to assist with most questions immediately. They will refer other questions to the appropriate staff for response, as needed.

Regional engineers are responsible for implementing the state drinking water program in assigned counties. They conduct sanitary surveys and special purpose investigations of public water systems and promote needed water facility improvements. They also review and approve water system plans and specifications for system improvements, and provide technical assistance to purveyors and local health jurisdictions, upon request.

For more information, visit the ODW website at

<http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/RegulationandCompliance/WaterworksOperatorCertification.aspx>

### Department of Health Office of Drinking Water – Regional Offices

#### **Eastern Regional Office**

16201 East Indiana Avenue Suite 1500  
Spokane Valley, Washington 99216  
**(509) 329-2100**

**Serving:** Adams, Asotin, Benton, Chelan, Columbia, Douglas, Ferry, Franklin, Garfield, Grant, Kittitas, Klickitat, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman and Yakima counties

#### **Southwest Regional Office**

PO Box 47823  
Olympia, Washington 98504-7823  
**(360) 236-3030**  
(243 Israel Rd., SE, Tumwater, WA 98501)

**Serving:** Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Kitsap, Lewis, Mason, Pacific, Skamania, Thurston and Wahkiakum counties

#### **Northwest Regional Office**

20435 72<sup>nd</sup> Avenue South Suite 200  
Kent, Washington 98032  
**(253) 395-6750**

**Serving:** Island, King, Pierce, San Juan, Skagit, Snohomish and Whatcom counties

### **Hotline for Drinking Water Emergencies**

#### **After-Hours or Weekends Only**

Toll-free 877-481-4901



# **Section 1 Water Systems**



# System Requirements

---

## Certification Applicability

The Waterworks Operator Certification Regulations (WAC 246-292) require the following Group A\* public water systems to have an appropriately certified operator(s) in responsible charge of daily operational activities:

- Group A community or nontransient noncommunity (NTNC) systems as defined by state rules (WAC 246-292-010)
- Group A transient noncommunity (TNC) systems classified as “state significant noncompliers” (SSNCs) as defined by state rules (WAC 246-292-010)
- Group A transient noncommunity (TNC) systems using surface water or groundwater under the influence of surface water (GWI) as defined by state rules (WAC 246-292-010)

**Note:** A designated certified operator(s) must be in responsible charge and available for each operating shift.

*\* The rules define Group A water systems as public water systems that serve a population of 25 or more and/or have 15 or more service connections.*

## Duties of the operator(s) in responsible charge

Public health is protected when competent operators operate public water systems. Drinking water rules require the person(s) in responsible charge of operating a water system to be certified. A “certified operator” is someone who has met the requirements for the specified operator classification of the Waterworks Operator Certification Program.

The operator(s) in “responsible charge” is the certified operator(s) the owner designates to make decisions about the daily operational activities of a public water system, water treatment facility, or distribution system. These are decisions that directly affect the quality or quantity of drinking water. This includes, but is not limited to decisions about process control and system integrity.

The certified operator in “responsible charge” of a public water system typically performs public health-related duties including, but not limited to the following:

1. Ensure all of the water system’s daily operational and maintenance activities are completed according to acceptable public health practices and water industry standards.
2. Perform water quality monitoring, maintain adequate records and take follow-up action, if necessary, to comply with state and federal drinking water regulations.
3. Implement preventative maintenance programs; and inspect treatment and other system components for malfunctions; keep adequate records; and make needed repairs.
4. Analyze and review recording-instrument readings and laboratory tests; determine sites and causes of any malfunctions; adjust various treatment processes or other components accordingly; and maintain a record of these.
5. Implement a cross-connection control program.
6. Determine and implement remedial actions in emergencies. This includes following directives DOH issues to address the situation.
7. Be available 24 hours per day (voicemail, cell phone).

## **Certified Operator Responsibilities**

All certified operators must operate the public water system(s) with due care and diligence for protecting public health and will abide by state and federal drinking water laws and regulations.

Certified operators shall operate the water system consistent with experience and training appropriate to their level of certification and must perform their duties according to state rules (WAC 246-292).

Failure to operate the water system according to state and federal drinking water laws and regulations could result in the suspension or revocation of their certification.

# System Classification

---

## Distribution Systems

Distribution systems convey water from the source and/or treatment facilities to consumers. The state Department of Health (DOH) classifies them into five groups based on population served:

Population Served*	Classification	Operator Certification Requirement
Less than 251	Group S	WDS
251 to 1,500	Group 1	WDM 1
1,501 to 15,000	Group 2	WDM 2
15,001 to 50,000	Group 3	WDM 3
More than 50,000	Group 4	WDM 4

\* We base population served on information public water systems provide on their Water Facilities Inventory (WFI) form. If the population served is unknown, multiply the number of service connections by 2.5.

## Purification Plants

Purification plants treat or improve the physical, chemical, or bacteriological quality of the system's water to bring it into compliance with State Board of Health standards.

The scope of the term, "purification plant," includes treatment processes installed to perform water filtration, ion exchange, electrodialysis, reverse osmosis, or iron and manganese removal. It does not include treatment processes installed to allow in-line fluoridation, in-line chlorination, or chemical additions to inhibit corrosion.

### DOH classifies purification plants into two categories

- Purification plants using basic filtration technology:**
  - A Basic Treatment Operator (BTO) certification is required for:
    - Group A systems with a Group 1 purification plant rating; or
    - An unfiltered Group A surface water or GWI system with fewer than 100 services in use at any one time.
  - A Water Treatment Plant Operator 1 (WTPO 1) certification is required for any unfiltered Group A surface water or GWI system with 100 or more services in use at any one time with a Group 1 purification plant rating.
- Purification plants using complex filtration technology:** A Water Treatment Plant Operator (WTPO) certification is required for any Group A public water system with a Group 2-4 purification plant rating.

DOH further classifies plants using complex filtration into four groups based on points. See the Association of Boards of Certification “Purification Plant Criteria” on pages 7 to 12.

<b>Purification Plant Rating Total Points Assigned</b>	<b>Classification</b>	<b>Operator Certification Requirement</b>
Less than 31	Group 1	BTO or WTPO 1
31 to 55	Group 2	WTPO 2
56 to 75	Group 3	WTPO 3
More than 75	Group 4	WTPO 4

### **Sample scenarios**

1. A water system serving 347 people and requiring no treatment other than chlorination requires a WDM 1.
2. A water system serving 136 people, with a Group 1 water purification plant rating and less than 100 services requires a WDS and a BTO.
3. A water system serving 136 people, with a Group 1 water purification plant rating and more than 100 services requires a WDS and WTPO 1.
4. A water system serving 1,550 people with a Group 2 water purification plant rating requires a WDM 2 and a WTPO 2.
5. A water system serving 26,000 people with a Group 3 water purification plant rating and three water treatment plant shift operators\* requires a WDM 3, a WTPO 3 and shift operators certified as WTPO 2.

*\* The operator in responsible charge for each operating shift must hold certification no lower than one level below the classification of the water purification plant or distribution system. Operating shift means continuous on-site performance of duties in a water purification plant or distribution system.*

## Guidelines for use of ABC Purification Plant Criteria Worksheet

### *APPLICABILITY OF THE WORKSHEET*

**WAC 246-292-010** defines "purification plant" as that portion of a public water system that treats or improves the physical, chemical, or bacteriological quality of the system's water to bring it into compliance with state board of health standards. Unit processes installed to perform filtration, ion exchange, electrodialysis, reverse osmosis, or iron and manganese removal are included in the scope of the term purification plant. **Unit processes installed to allow in-line fluoridation, in-line chlorination, or add a chemical to inhibit corrosion are not included in the scope of the term purification plant.** Exception: a treatment operator shall be responsible for operation of any *unfiltered* Group A surface water or GWI system (WAC 246-292-050).

**For multiple treatment facilities** on same system: plants are rated individually, however whole system population is used unless the portion of a system served by a particular plant is physically isolated and its service population is known. Operators in systems having multiple treatment facilities must either be assigned to a specific plant, or must be certified for the highest-rated plant on that system. The Waterworks Operator Certification Program maintains rating records for all plants, but classifies systems on the basis of the highest-rated plant.

**If a process is provided remotely**, but is integral to treatment, then consider it part of the treatment plant (e.g. chlorination in a raw water pipeline used for CT compliance). However, if treatment is supplemental in nature, and operation and monitoring is provided separately from the plant, then this may be considered not a part of the treatment plant (e.g. chlorination at a remote booster station).

### SIZE

**Maximum population served.** Total population receiving water from the plant, including the population served by any consecutive systems.

**Design flow.** The design capacity of the plant.

### WATER SUPPLY SOURCES

**Groundwater.** Only give points if there is treatment (i.e. "purification") for a primary contaminant, including seawater and saltwater sources.

**Average raw water quality variability.** Applies to all sources (surface and groundwater). Key is the effect on treatment process changes that would be necessary to achieve optimized performance.

- Little or no variation - no treatment provided except disinfection - (0 points)
- Minor variation - e.g. "high quality" surface source appropriate for slow sand filtration - (2 points)
- Moderate variation - chemical feed dosage changes made: at least weekly (3 pts), daily (4 pts), or with each 8-hour shift (6 pts)
- High variation – requires frequent changes in treatment (several times daily), raw water quality variability may be due to agricultural and/or municipal waste discharges - (8 points)
- Extreme variation – may be from periodic serious industrial, agricultural or municipal waste pollution - (10 points)

**Raw water is subject to or has elevated.** If typically occurring on a routine basis;

- **Taste and/or odor levels** will be considered elevated when: 1) Taste and odor (T&O) issue has been identified in a pre-design report, etc., 2) a process has been installed to address, and 3) operational control adjustments are made at least seasonally. Do not give points for T&O when there is no specific additional impact on operation. For example, if a system is already pre-chlorinating for disinfection, give no points for T&O.
- **Color** will be considered elevated when levels exceed 75 Color Units (CU) for conventional filtration, 40 CU for direct filtration, or 15 CU for all other technologies, except reverse osmosis (no limits).
- **Iron and/or Manganese.** Except for applications of manganese greensand treatment, will be considered elevated when their combined level exceeds 1.0 mg/l. (No limits apply for Mn/greensand systems.)
- **Turbidity.** No restrictions or limitations apply for conventional filtration. Turbidity will be considered elevated when levels exceed 14 NTU for direct and in-line filtration, 10 NTU for slow sand filtration, and 5 NTU for pre-coat (diatomaceous earth), cartridge, and bag filters. Limits do not apply to membrane technologies. Note these values apply for turbidity not due to precipitated metals. For unfiltered systems: apply points only if source *blending or source shutdown* is used to achieve/maintain SWTR compliance.
- **Coliform** will be considered elevated when levels exceed 20,000 CFU/100 mL (as total coliform) for conventional filtration, 5,000 for direct filtration, 500 for direct and in-line filtration, 800 for slow sand filtration, and 50 for pre-coat (diatomaceous earth), cartridge and bag filters. Limits do not apply to membrane technologies. For unfiltered: Fecal coliform levels that trigger a “filtration decision.”
- **Algal growths.** Raw water will be considered subject to algae growths when treatment processes are specifically adjusted due to the presence of high levels of algae on at least a weekly basis for at least two months each year.

**Raw water is subject to periodic pollution:** Points are to be accrued when a source of pollution is “consistent enough to cause problems that need to be addressed by the operator” on at least a daily basis.

## CHEMICAL TREATMENT/ADDITION PROCESS

**Chemical addition** – 1 point (each) for any coagulant, coagulant aid, flocculent, or filter aid.

**Liquid or powdered chlorine** includes on-site generated hypochlorites, and tablet feeders.

**UV Disinfection** – 5 points.

**pH adjustment** – chemical addition for process control purposes (e.g. pH adjustment aids coagulation)

**Chloramination** – 5 points, same as chlorination/chlorine dioxide.

**KMnO<sub>4</sub>** – 2 points. If used with greensand filtration do not give 2 points.

**Stability or Corrosion Control** – If the same chemical is used for both Corrosion Control and pH adjustment, count points only once - for Corrosion Control (10 points).

## **COAGULATION & FLOCCULATION PROCESS**

**Mechanical mixers** are motor driven, turbine or propeller mixers. Also known as back-mixers.

**Injection mixers** are those that use diffusion mixing by pressurized water jets.

**In-line blender mixers** are in-pipe motor-driven impeller rapid mixers. These do not include in-line static (motionless) mixers. Static mixers get zero points, as do hydraulic mixers (Parshall flume, venturi, and weir).

**Hydraulic flocculators** include horizontally and/or vertically baffled channels, pipe nozzles, and windowed baffles.

**Mechanical flocculators** include shaft driven turbines, blades or paddles (including Walking Beam).

## **CLARIFICATION/SEDIMENTATION PROCESS**

**Up-flow solid-contact sedimentation** is also known as sludge blanket clarification. Includes such proprietary units as Super-Pulsator. These units include processes for flocculation and sedimentation. Important note: these are not the same as adsorption clarifiers.

Adsorption clarifiers – give 10 points under Special processes/other.

Other proprietary clarification processes – Actiflo, etc. Give 10 points under Special processes/other.

## **FILTRATION PROCESS**

**Single media filtration.** Sand filter used in complete conventional filtration. Also simple single media processes such as Pyrolox® (pyrolusite) or Birm® filtration –but not greensand (see below). Does not include deep bed monomedia (see “Direct Filtration”), or slow sand filtration.

**Microscreens** includes membrane filtration (microfiltration and/or ultrafiltration), but not RO (see below).

**Cartridge filters** includes bag filtration. With or without any non-chemical pre-filtration (e.g. staged cartridges, pressure sand filtration).

**Direct filtration** includes in-line filtration and deep bed monomedia filtration.

**Pressure or greensand filtration** – Pressure filtration (for surface sources), and manganese greensand oxidative filters (with or without anthracite cap) –20 points. Points assigned for greensand filtration assume a complete process train, including pretreatment (pre-oxidation), filtration and residuals disposal, but not fluoridation, disinfection, or corrosion control.

## **SPECIAL PROCESSES**

**Other.** For processes not specifically listed, assign 2 – 15 points based upon comparison with equivalent treatment of similar complexity.

## **RESIDUALS DISPOSAL**

Pick the one category (out of the eight) that best represents disposal practice at the plant.

**Discharge to raw water source** - can be recycling to plant, or to lake/reservoir.

**On-site disposal** – pertains to dry solids residuals disposal.

**Land application** – pertains to liquid residuals disposal (and there is no NPDES permit).

## **FACILITY CHARACTERISTICS**

**No process operation** – plant has no automated shutdown capability.

**Limited process operation** – automated alarm and shutdown for turbidity, chlorine, level, etc.

**Moderate process operation** – alarms and shutdown, plus partial remote operation of plant.

**Extensive/total process operation** – alarms and shutdown, full remote operation of plant possible.

**Clearwell size** applies only to systems treating for a primary contaminant. Total distribution storage available prior to first customer may be counted if it may be drawn upon. If there is no clearwell, points are given.



WASHINGTON STATE DEPARTMENT OF HEALTH  
**ABC Purification Plant Criteria Worksheet**

**ABC Classification:**

Water Treatment Plant - address and contact person	
Plant Name	WA WFI #
Contact Name and Title	
Address	
City/State/Zip	
Phone and Fax	

A groundwater supply with only chlorination is considered a distribution system, not a water treatment facility. The addition of any chemical to a public water supply, other than a disinfectant, will be considered a treatment facility and should use this rating worksheet to determine the classification of the facility\*. Unless otherwise noted, give full amount of points in the "Your Plant" box.

For example:

	Raw water quality is subject to or has elevated:	Points	Your Plant
Correct:	Taste and/or odor levels	3	3
Incorrect:	Taste and/or odor levels	3	1

Do not double count. If the plant has two horizontal-flow (rectangular basins), **DO NOT** give 10 points, give 5 points. If the plant has more than one type of unit for each process, give points once for each unit.

\*With the exception of unit processes installed to allow in-line fluoridation, in-line chlorination, or chemical addition to inhibit corrosion are not included within the scope of the term "purification plant" per WAC 246-292-010.

Item	Points	Your Plant
<b>Size (2 point minimum to 20 point maximum)</b>		
Maximum population or part served, peak day (1 pt minimum to 10 pt maximum) Examples: 27,000 people served = 3 pts      13,000 people served = 2 pts (Round up to the next whole number)	1 pt per 10,000 or part	
Design flow average day or peak month's part flow average day, whichever is larger (1 pt minimum to 10 pt maximum) Examples: 9.2 MGD = 10 pts      4.7 MGD = 5 pts (Round up to the next whole number)	1 pt per MGD or part	
<b>Water supply sources</b>		
Groundwater	3	
Groundwater under the influence of surface water	5	
Surface water	5	
Average raw water quality varies enough to require treatment changes 10% of the time with a range of 0 to 10 with the following guidelines: Little or no variation = 0 points High variation. (Raw water quality subject to periodic serious industrial waste pollution) = 10 points	0—10	
Raw water quality is subject to or has elevated:		
• Taste and/or odor levels	3	
• Color levels	3	
• Iron and/or manganese levels	5	
• Turbidity levels	5	
• Coliform and/or fecal counts	5	
• Algal growths	5	
Raw water quality is subject to periodic:		
• Industrial and commercial waste pollution	5	
• Agricultural pollution	5	
• Urban runoff, erosion, and storm water pollution	3	
• Recreational use (boating, fishing, etc.)	2	
• Urban development and residential land use pollution	2	
<b>Chemical Treatment/Addition Process</b>		
Fluoridation	5	
Disinfection		
• Gaseous chlorine	5	
• Liquid or powdered chlorine	5	
• Chlorine dioxide	5	
• Ozonization (on-site generation)	10	
pH adjustment (Calcium carbonate, carbon dioxide, hydrochloric acid, calcium oxide, calcium hydroxide, sodium hydroxide, sulfuric acid, other)	5	
Stability or Corrosion Control (Calcium oxide, calcium hydroxide, sodium carbonate, sodium hexametaphosphate, other)	10	

**PURIFICATION PLANT CRITERIA WORKSHEET (cont.)**

<b>Coagulation &amp; Flocculation Process</b>		
Chemical addition (1 pt for each type of chemical coagulant added, maximum 5 pts) (Aluminum sulfate, bauxite, ferrous sulfate, ferric sulfate, calcium oxide, bentonite, calcium carbonate, carbon dioxide, sodium silicate, other)	5	
Rapid mix units		
• Mechanical mixers	3	
• Injection mixers	2	
• In-line blender mixers	2	
Flocculation tanks		
• Hydraulic flocculators	2	
• Mechanical flocculators	3	
<b>Clarification/Sedimentation Process</b>		
Horizontal-flow (rectangular basins)	5	
Horizontal-flow (round basins)	7	
Up-flow solid-contact sedimentation	15	
Inclined-plate sedimentation	10	
Tube sedimentation	10	
Dissolved air flotation	30	
<b>Filtration Process</b>		
Single media filtration	3	
Dual or mixed media filtration	5	
Microscreens	5	
Diatomaceous earth filters	5	
Cartridge filters	5	
Slow sand filters	5	
Direct filtration	5	
Pressure or greensand filtration	20	
<b>Other Treatment Processes</b>		
Aeration	3	
Packed tower aeration	5	
Ion-exchange/softening	5	
Lime-soda ash softening	20	
Copper sulfate treatment	5	
Powdered activated carbon	5	
<b>Special Processes (reverse osmosis, electrodialysis, other)</b>	15	
<b>Residuals Disposal</b>		
Discharge to lagoons	5	
Discharge to lagoons and then raw water source	8	
Discharge to raw water	10	
Disposal to sanitary sewer	3	
Mechanical dewatering	5	
On-site disposal	5	
Land application	5	
Solids composting	5	
<b>Facility Characteristics</b>		
Instrumentation (Choose only one of the following)		
• Use of SCADA or similar instrumentation systems to provide data w/ no process operation	0	
• Use of SCADA or similar instrumentation systems to provide data w/ limited process operation	2	
• Use of SCADA or similar instrumentation systems to provide data w/ moderate process operation	4	
• Use of SCADA or similar instrumentation systems to provide data w/ extensive or total process operation	6	
Clearwell size less than average day design flow	5	
	Total Points	

See WAC 246-292-050 for minimum certification requirements:

(Revised 07.10.02)

Class I ..... 30 points or less

Class III ..... 56-75 points

Class II ..... 31-55 points

Class IV ..... 76 points and greater

Form Completed by: \_\_\_\_\_ Date: \_\_\_\_\_

## System Temporary Operator Certification

---

If the certified operator(s) in responsible charge of a water system leaves the position for any reason, the system must fill the vacant position within 30 days. The system must report this change **in writing** to the Waterworks Operator Certification Program (Certification Program). To stay in compliance, the system must hire an appropriately certified operator, a contract operator, or apply for temporary certification for an individual who is not properly certified, but meets the certification requirements.

When a system wishes to hire an uncertified operator, or an operator not certified at the appropriate level, DOH **may** issue a temporary certification on request by the system. To obtain an application for temporary certification contact the Waterworks Operator Certification Program (see address and phone number on page *ii*).

To request a temporary certification, the system must submit the following to the Certification Program:

- A letter requesting temporary certification for the operator
- The temporary certification application (signed by the operator and the system representative)
- Temporary application fee

The program will grant temporary certification only if DOH criteria are met. DOH will issue only one temporary certification in each instance of any position vacancy and it may be valid for up to 12 months (normally from the date the position became vacant).

DOH may issue temporary certification to transient noncommunity systems classified as state significant noncompliers (SSNCs) for up to four months.

## System Certification Fees

---

### Water System Fees

We charge the Group A system fees below. These fees are subject to change.

<b>System Size*</b> (Number of Equivalent Services)	<b>System Fee**</b>
Less than 601 Services	\$132.00
601 through 6,000 Services	\$403.00
6,001 through 20,000 Services	\$536.00
More than 20,000 Services	\$809.00

*\*Systems DOH designates as approved satellite management agencies (SMAs) must pay a fee based on total services in all systems owned by the SMA.*

*\*\*DOH bases the late fee on the water system's classification. It will be an additional 10 percent of the system fee or \$35.00, whichever is greater.*

A Group A system must pay the annual system fee with the system's annual operating permit fee (WAC 246-294).

The system fee for issuance of a temporary certification shall be \$87.00 for each temporary position.

# System Compliance and Enforcement

---

The Department of Health Office of Drinking Water and the U.S. Environmental Protection Agency (EPA) consider compliance with the operator certification rules (WAC 246-292) a high priority. The Waterworks Operator Certification Program (Certification Program) provides quarterly compliance reports to EPA documenting system compliance and enforcement efforts.

All systems and certified operators must provide complete, accurate information to the Certification Program. The water system representative must report all changes related to the position(s) of operator in responsible charge. **You must report all changes in writing** (see address on page *ii*).

The program sends all water system enforcement or compliance-related documents to the system's mailing address. The program sends all operator information, including renewals, certificates, and professional growth status to the operator's home mailing address.

## The Certification Program's compliance and enforcement process

### Phase 1 – Informal Notification Letters and Telephone Calls

The Certification Program notifies and provides technical assistance to systems that may be out of compliance with the operator certification rules. DOH sets compliance dates and Certification Program staff helps systems and operators achieve compliance.

### Phase 2 – Notice of Violation (NOV)

At Phase 2, it is clear that a violation of the operator certification rules has occurred. We issue NOVs to systems that refuse to respond to Certification Program contacts or consistently exceed scheduled compliance dates. There are limited compliance options available at this point.

### Phase 3 – State Significant Noncomplier (SSNC)

The Certification Program categorizes water systems that fail to respond to a Notice of Violation as a SSNC. We notify the system that it is out of compliance. Status as a SSNC for lack of a certified operator results in the operating permit being categorized as "red." A red operating permit can affect such things as new loan applications, building permits, and sewage permits.

### Phase 4 – State Departmental Order (SDO)

Systems that receive an SDO from the Certification Program are SSNCs.

### Phase 5 – Notice of Imposition of Penalties (NIP)

Systems that receive a NIP for noncompliance with the operator certification rules may face civil penalties of up to \$5,000 per day, per violation. Prosecution as a criminal misdemeanor with fines up to \$100 per offense can also be pursued (WAC 246-292-110 (4), (5)).

The Attorney General's Office or local prosecutor can pursue other legal actions (WAC 246-292-110 (7)).



## **Section 2 Waterworks Operators**

## Duties of the Operator(s) in Responsible Charge

---

Public health is protected when competent operators operate public water systems. Drinking water rules require the person(s) in responsible charge of the operation of the water system to be certified. A “certified operator” is someone who has met the requirements for the specified operator classification of the Waterworks Operator Certification Program.

Drinking water rules require the person(s) in responsible charge of the operation of the following water systems to be certified:

- Group A community or nontransient noncommunity (NTNC) water system
- Group A transient noncommunity (TNC) water system classified as a state significant noncomplier (SSNC)
- Group A transient noncommunity (TNC) water system using a surface water or groundwater under the influence of surface water (GWI).

Once certified, all operators must meet renewal and professional growth requirements (see pages 30-35).

The operator(s) in “responsible charge” is the certified operator(s) the owner designates to make decisions about the daily operational activities of a public water system, water treatment facility, or distribution system. These are decisions that directly affect the quality or quantity of drinking water. This includes, but is not limited to, decisions about process control and system integrity.

The certified operator in “responsible charge” of a public water system typically performs public health-related duties including, but not limited to the following:

1. Ensure all of the water system’s daily operational and maintenance activities are completed according to acceptable public health practices and water industry standards.
2. Perform water quality monitoring, maintain adequate records and take follow-up action, if necessary, to comply with state and federal drinking water regulations.
3. Implement preventative maintenance programs; and inspect treatment and other system components for malfunctions; keep adequate records; and make needed repairs.
4. Analyze and review recording-instrument readings and laboratory tests; determine sites and causes of any malfunctions; adjust various treatment processes or other components accordingly; and maintain a record of these.
5. Implement a cross-connection control program.
6. Determine and implement remedial actions in emergencies. This includes following directives DOH issues to address the situation.
7. Be available 24 hours per day (voicemail, cell phone).

## **Certified Operator Responsibilities**

---

All certified operators must operate the public water system(s) with due care and diligence for protecting public health and will abide by state and federal drinking water laws and regulations.

Certified operators must operate the water system consistent with experience and training appropriate to their level of certification and must perform their duties according to state rules (WAC 246-292).

Failure to operate the water system according to state and federal drinking water laws and regulations could result in the suspension or revocation of their certification.



## Contract Operator

---

Contract operators are certified operators in responsible charge of three or more public water systems (WAC 246-292-055).

At a minimum, a contract operator must:

1. Be certified as a Water Distribution Manager (WDM) (level determined by the largest public water system being operated) and Cross Connection Control Specialist (CCS).
2. Be available 24 hours per day (message phone, cell phone).
3. Provide two copies of signed operations contracts to the Waterworks Operator Certification Program (Certification Program) for each system operated within 30 days of the effective date of the contract.

Additionally, a Basic Treatment Operator (BTO) or Water Treatment Plant Operator (WTPO) may be needed depending on the specific systems operated.

**These requirements also apply to operators in responsible charge of Satellite Management Agencies.**

**To obtain a list of contract operators** who asked to be included on a DOH contract operator public listing, contact the Waterworks Operator Certification Program (see page ii) or visit the website at <http://www.doh.wa.gov/Portals/1/Documents/4200/contract-op.pdf>

## **Education and Experience Requirements**

---

Minimum education and experience requirements for certification ensure safe, efficient, and effective operation of public water systems.

State drinking water rules set the following minimum education and experience requirements for each waterworks operator classification and level (WAC 246-292-060 (1)).

CLASS	LEVEL									
	Operator In-Training*		1		2		3		4	
	Education	Experience	Education	Experience	Education	Experience	Education	Experience	Education	Experience
WDM	12 years	3 months	12 years	1 year	12 years	3 years	14 years	4 years	16 years	4 years
WTPO	12 years	3 months	12 years	1 year	12 years	3 years	14 years	4 years	16 years	4 years

\* *Operator In-Training (IT) experience may be fulfilled with three months of operating experience or 30 hours of relevant classroom training (three relevant continuing education units (CEU) or college credits).*

Water Distribution Specialist (WDS)		Basic Treatment Operator (BTO)		Cross-Connection Control Specialist (CCS)	
Education	Experience	Education	Experience	Education	Experience
12 years	6 months	12 years	6 months	12 years	6 months

**NOTE:** 12 years education means a high school diploma, GED, or equivalent.

Applicants for Level 1 certification may not substitute equivalent experience or relevant college for any portion of the operating experience requirement. **Operating experience shall be the routine on-site performance of duties in a water purification plant or distribution system. Those duties affect plant or system performance and/or water quality.**

Applicants for Water Treatment Plant Operator 2-4 must obtain at least half the required operating experience at a public water purification plant that uses complex filtration technology. This experience must be at a level no more than one classification lower than the level of certification they are seeking.

Following one year of operating experience, applicants for Levels 2, 3, or 4 may make substitutions (see ***Substitutions for Education and Experience*** on pages 24-25).

College credits or CEU in coursework that meets the following requirements:

1. Has an influence on water quality, water supply, or public health protection; **and**
2. Is directly relevant to the operation or maintenance of a water system; **or**
3. Is directly relevant to managing the operation or maintenance activities of a water system.

College credits or CEU claimed by an applicant may be credited toward the certification requirements when documented on an official transcript (or unaltered copy) and/or acceptable certificates of completion. **DOH accepts only relevant college credits or relevant continuing education units (CEU). We will not accept contact hours, professional development hours, or other forms of accreditation.**

DOH may allow substitutions of a person's relevant experience when the person cannot meet the formal education requirement, or substitute relevant education for experience, in the WDM, WTPO, WDS, BTO, and CCS classifications (see *Substitutions for Education and Experience* on pages 24-25).

## Substitutions for Education and Experience

---

### Accepted Education Substitutions

1. A GED is equivalent to a high school diploma.
2. One year of excess operating experience may be substituted for one year of high school or two years of grade school—no limit. **Option 2 below requires a high school diploma or GED.**
3. Applicants for Level 3 and 4 certification may use *one* of the following education substitution options:

**Option 1:** Applicants may substitute one year of excess experience operating a water purification plant or distribution system for one year of required relevant college education. They can use this substitution for **up to half of the education requirement**. Option 2 is required if the applicant has less than half of the required college education.

**Option 2:** Applicants must verify their high school diploma or GED. Three years of excess experience operating a water purification plant or distribution system equals one year of college. This experience must be no more than one classification lower than the level of certification they are seeking. For example, to apply for a WTPO 3, your experience must be at least at the WTPO 2 level—**no limit**.

**Note:** Excess operating experience substituted for a WTPO classification must be in a public water purification plant classified at the appropriate level. To determine eligibility using either option, contact the Waterworks Operator Certification Program (see page *ii*).

4. One year of college will mean 30 relevant semester credits, 45 relevant quarter credits, or 45 relevant continuing education units (CEU).
5. DOH accepts only relevant college credits or relevant CEU. Contact hours, professional development hours, or other forms of accreditation **will not be accepted**.
6. You may apply on-the-job training that receives college or CEU credit towards an education requirement or an experience requirement, but not to both.

### Accepted Experience Substitutions

1. You may substitute three relevant CEU or college credits for the three months of operating experience required for Operator In-Training applicants.
2. Applicants for Water Treatment Plant Operator 2-4 may substitute relevant experience, college credits, CEU, or a combination of education and experience for up to half the required experience.

3. Applicants for Water Distribution Manager 2-4 that obtain one year of operating experience may substitute relevant experience, college credits, CEU, or a combination of education and experience year for year. **Option 2 above requires a high school diploma or GED.**
4. If one year of operating experience has been obtained, the following **water-related** experience may be credited:
  - A. Water-related experience in a federal, state, county, local, or other government agency
  - B. Water-related experience as an operations consultant
  - C. Water-related experience in other areas such as design, analysis, planning, construction, administration, management and so on.

## Operator Certification Fees

---

We charge operators the fees below. These fees are subject to change.

### Fee Schedule

Operator Classification	Application Fee	Reapplication Fee	Annual Renewal Fee	Renewal Late Fee
WTPO	\$87.00	\$42.00	\$42.00*	\$35.00**
WDM	\$87.00	\$42.00	\$42.00*	\$35.00**
WDS	\$87.00	\$42.00	\$42.00*	\$35.00**
CCS	\$51.00	\$42.00	\$42.00*	\$35.00**
BTO	\$51.00	\$42.00	\$42.00*	\$35.00**

\* The annual renewal fee for a WTPO, WDM, WDS, BTO, and CCS certification is \$42.00 regardless of the number of classifications held.

\*\* The late fee for the WTPO, WDM, WDS, BTO, and CCS certification is \$35.00 regardless of the number of classifications held.

**A separate exam fee** is required for each exam. Operators must submit the exam fee with the application and application fee (see the instructions in the application packet). These fees are subject to change.

**A late renewal fee** is assessed to operators failing to submit the required fee within the period specified on the renewal form. Failure to notify the Waterworks Operator Certification Program of a change of address **in writing** does not constitute a reasonable excuse for failure to renew a certificate prior to assessment of the renewal late fee. **DOH will not consider appeals from operators assessed the late fee or failure to renew due to an unreported address change.**

**The application fee for reciprocity** is \$177.00 per classification.

**The application fee for automatic upgrade** (WTPO-IT to WTPO 1 and/or WDM-IT to WDM 1) is \$87.00.

## Reciprocity with Other States

---

We may issue a certificate without exam, if the applicant holds a valid waterworks operator certification issued under the laws of another state or province, and all of the following requirements are met:

- The out-of-state education, operating experience, and professional growth requirements are equal to, or more stringent than Washington state rules (WAC 246-292).
- The applicant passed the appropriate Association of Boards of Certification (ABC) exam with the equivalent passing score.
- An application and supporting documents have been submitted with proof of a valid waterworks certification and the appropriate reciprocity fee.

We will notify an applicant who is denied reciprocity of certification options.



## Application and Exam Process

---

A person seeking waterworks certification should follow this procedure. It includes responsibilities for the applicant and Department of Health (DOH).

1. The person seeking waterworks certification must submit the following items to the Waterworks Operator Certification Program (Certification Program):
  - A. DOH's **current** waterworks certification application and supporting documents.
  - B. Application and ABC exam fees (two separate fees). **Note: The DOH application fee is not refundable or transferable. The ABC exam fee is refundable, if the application is denied.**
  - C. When required, an official or unaltered copy of college or other transcripts.
2. DOH purchases certification exams from the Association of Boards of Certification (ABC). The ABC exam fee is subject to change.
3. DOH schedules three exams a year. Exams usually are the first Tuesday of February, June, and October. **There may be times when exams are another day of the week due to exam room availability. If this occurs, DOH will notify the applicant of the change.**
4. Applications to the Certification Program **must be postmarked no later than the application deadline** listed on the application instructions. Applications postmarked after the deadline will be processed for the next available exam date.
5. Incomplete applications will be returned to the applicant. They must be resubmitted and postmarked by the application deadline. Those postmarked after the deadline will be processed for the next available exam date.
6. About three weeks before the exam, DOH will send all applicants a letter confirming the approved exam, time, date, and exam location.
7. Exams will not be given to individuals who appear for an exam without a written scheduling notice. If an individual takes an exam without proper authorization from the Certification Program, DOH will destroy the exam answer sheet before it is graded.
8. Exams will be closed book. The exam formulas and conversion factors are in each exam booklet and **Appendix I** of this publication.
9. Hand-held numeric calculators are allowed. Text-entry programmable calculators such as laptops, electronic organizers or the equivalent may not be used.
10. All exam applicants must provide picture identification (driver license, military identification card, or other government issued identification) prior to taking the exam. **Applicants who do not have picture identification must obtain approval from the Certification Program two weeks before the exam.**

11. The Americans with Disabilities Act allows exam applicants to request special accommodation for a documented disability. DOH requires applicants requesting special accommodations to submit the Request for Accommodation forms, which include current documentation of the disability from an individual qualified to assess the disability. The documentation must identify the diagnosis and nature of the disability, the last time the provider saw the applicant, the name of the test used to diagnose the disability, the duration of the condition, and the recommended accommodation. A physician or licensed health care provider appropriate to the disability must provide documentation on professional letterhead.

If DOH allows special exam accommodation, it will set the time and place it considers appropriate to address the applicant's needs.

**You must submit the completed Request for Accommodation forms to DOH with the exam application by the application deadline.**

12. Exam subject information and study materials are in **Appendices A through I**. Operators certified at the "In-Training" level (WDM-IT or WTPO-IT) can apply for automatic upgrade to Level 1 after they meet the education and experience requirements. Applicants must complete an Automatic Upgrade Application and submit it to the Certification Program along with a current Affidavit of Employment and the appropriate fee. The effective date of the upgrade will be the date the application is approved.

# Certification Renewal Process

---

All certified waterworks operators must renew their certificates January 1 of each year.

## Renewal Notices

The Department of Health (DOH) will mail the first renewal notice to the *operator's home mailing address* the second week of November. If payment is not postmarked by the deadline listed on the first renewal notice, a second and final renewal notice will be mailed.

DOH will charge a late fee to operators failing to submit the required renewal fee within the period specified on the first renewal notice.

We will charge the operator any additional fees DOH incurs for checks returned for non-sufficient funds (NSF). All fees must be paid in full by the final renewal deadline.

**Failure to pay the renewal fee by the final deadline or meet the professional growth requirement within the designated timeframe is not eligible for appeal.**

## Certificate Renewal

DOH will renew the operator's certificate annually when it receives the renewal fee payment by the specified deadline. A certification validation card will be issued for the renewal year.

**During the deadline year of a professional growth reporting period, an operator's renewal will not be mailed until the operator meets the professional growth requirement.**

DOH will notify operators failing to renew their certificate that it is temporarily valid for two months beginning January 1. A certificate not renewed during the two-month period will become invalid. DOH will send written notice informing the operator the certificate is no longer valid.

Operators failing to renew their certification may reapply for certification and must meet the requirements of a new applicant (WAC 246-292-090).

## Changes in address, employer, or phone number

Operators must keep DOH informed of their current home mailing address, employer, and phone number. You must report changes in writing. **Failure to notify DOH of a change of address does not constitute a reasonable excuse for waiver of the late fee assessment, failure to renew a certificate, or failure to demonstrate professional growth.**

## Professional Growth

---

The Waterworks Operator Certification Program requires certified operators to demonstrate continued professional growth in the field to be eligible for certification renewal. Washington Certification Services at Green River Community College (GRCC) in Auburn administers the waterworks professional growth program through an interagency agreement with Department of Health (DOH), Office of Drinking Water. Washington Certification Services follows the rules, policies, and procedures DOH established in cooperation with the Waterworks Operator Certification Advisory Committee. GRCC maintains individual professional growth transcripts for each certified operator and provides course evaluation and continuing education unit (CEU) assignment services to relevant waterworks training courses.

### Professional growth requirement for certified waterworks operators

To meet the professional growth requirement, each certified waterworks operator must accomplish one of the following within the timetable listed below:

Option 1: Accumulate a minimum of three continuing education units (CEU) or college credits for training that:

1. Has an influence on water quality, water supply, or public health protection; **and**
2. Is directly relevant to the operation, or maintenance of a water system; **or**
3. Is directly relevant to managing the operation, or maintenance activities of a water system.

For more information, see DOH fact sheet **Relevancy of Training for Certified Waterworks Operators (331-186)**.

Option 2: Advance by exam in the Waterworks Operator Certification Program to a Level 2, 3 or 4, or achieve certification by exam in a different classification as follows:

- WDM to WTPO, BTO or CCS
- WTPO to WDM or CCS
- BTO to WDM, WTPO, WDS or CCS
- WDS to WDM, WTPO, BTO or CCS
- CCS to WDM , WTPO, BTO or WDS

### When certified operators must meet their professional growth requirement:

If your original certification date is:	Then you must meet the professional growth requirement between:
Before 1/1/2010	1/1/2013 and 12/31/2015 and in each 3-year reporting period thereafter.
1/1/2010 - 12/31/2012	Your original certification date and 12/31/2015 and in each 3-year reporting period thereafter.
1/1/2013 - 12/31/2015	Your original certification date and 12/31/2018 and in each 3-year reporting period thereafter.

## Course Evaluation and CEU Assignment

DOH requires that classroom training used to meet a waterworks operator's professional growth requirement for renewal, or education requirement for certification, have continuing education units (CEU) assigned either by Washington Certification Services or by the training course sponsor. DOH also accepts relevant college credit awarded by an accredited college or university. **Contact hours, professional development hours (PDH), or other forms of accreditation will not be accepted.**

CEU assigned to classroom training by the course sponsor may be accepted if it is based on a formal evaluation process following the minimum guidelines established by the **International Association of Continuing Education and Training (IACET)**.

Washington Certification Services evaluates relevant classroom training and conferences held in Washington, and distance education, based on the guidelines and procedures established by the Department of Health (DOH). **Washington Certification Services does not evaluate classroom training held outside of Washington except in specific cases approved by DOH.** The course sponsor must submit all requests for course evaluation and CEU assignment to Washington Certification Services.

Requests for course evaluation received past the deadlines below will be returned to the sponsor without evaluation.

- Requests for evaluation of classroom training must be **received at least 15 calendar days** in advance of the training.
- Requests for evaluation of multi-session conferences must be **received at least 45 calendar days** in advance of the conference.
- Sponsors of distance education must allow a minimum of **45 calendar days** for evaluation.

Washington Certification Services issues an identification number to each course that is evaluated and assigned CEU. The course sponsor must refer to this identification number on the *Waterworks Operator Professional Growth Training Roster* submitted at the end of each training session, and on all correspondence or inquiries regarding the CEU assignment.

CEU assignments for courses evaluated by Washington Certification Services will be valid for three years from the date of the original CEU assignment. The original assignment will be considered invalid within the three-year period if the sponsor, title, content, or the length of the course changes, or if the course no longer meets current DOH evaluation criteria. At the end of the 3-year period, course sponsors must submit a new *Request for Course Evaluation and CEU Assignment*.

## Submitting Completed Training

### Classroom Training Submitted by the Course Sponsor

Washington Certification Services evaluates and assigns CEU to waterworks training in Washington. The sponsor must submit verification of successful completion of training that Washington Certification Services has evaluated. The *Waterworks Operator Professional Growth Training Roster* form is available from Washington Certification Services. The sponsor should submit it within 30 days of the training date.

### Classroom Training Submitted by the Operator

The operator may ask Washington Certification Services to evaluate out-of-state training or training the course sponsor did not submit for evaluation in advance. To do this the operator must submit a completed *Waterworks Classroom Training Submittal Form* to Washington Certification Services. Washington Certification Services will use DOH and IACET criteria to review the training curriculum and documentation of CEU or college credit earned. Washington Certification Services may accept training that meets the criteria toward the operator's professional growth requirement. The form is available from Washington Certification Services.

### Distance Education

DOH must pre-approve all distance education, and operators must complete the training according to DOH's *Distance Education Approval and Exam Procedure*. Distance education not pre-approved or completed following these procedures **will not be accepted** toward the operator's professional growth requirement and cannot be appealed.

Distance education includes online training, CD-ROM, videotape, or correspondence courses. A current list of approved distance education courses, the CEU accepted in Washington, procedures and submittal forms are available from Washington Certification Services.

### CEU Reporting

It is the certified operator's responsibility to satisfy the professional growth requirement by December 31 of the reporting period deadline year. Training completion and certification exam documentation is reported to Washington Certification Services as follows:

- The training sponsor or operator must submit verification of successful course completion following DOH procedures.
- Washington Certification Services will evaluate all verification of CEU or college credit submitted based on criteria established by DOH and by the IACET. CEU or college credit meeting DOH and IACET criteria may be accepted toward the operator's professional growth requirement.
- DOH will notify Washington Certification Services of all certified operators who meet the professional growth requirement by passing a certification exam, using Option 2 as shown on page 31.

## CEU Recording

The Department of Health accepts only continuing education units (CEU) or college credit awarded to relevant waterworks training toward the professional growth requirement. The following will **not** be accepted for recording:

- Contact hours, professional development hours, or other forms of accreditation
- CEU or college credit earned prior to the operator's original certification date
- CEU or college credit not earned in the operator's current professional growth reporting period
- CEU awarded less than 0.3
- CEU not awarded based on IACET criteria
- CEU or college credit earned for course repeated in the same reporting period
- College credit not issued by an accredited college or university

Certified operators who meet the professional growth requirement using CEU or college credit earned for completion or instruction of classroom training may repeat the same course **in a different reporting period**. CEU equal to one-half of the original assignment may be applied toward the professional growth requirement in a different reporting period. **No CEU will be accepted for courses repeated if half the original CEU assignment is less than 0.3, repeated during the same reporting period, or for repeating any distance education activities.**

DOH directs Washington Certification Services to restrict record keeping to that required by a certified operator to meet the professional growth requirement specified by law. Therefore, after an operator has met the professional growth requirement for certification renewal for the current reporting period, Washington Certification Services will not accept documentation of additional training for the remainder of that reporting period. It is the operator's responsibility to keep track of training beyond that required to meet the professional growth requirement.

## Notification and Deadlines

When a certified operator satisfies the professional growth requirement, Washington Certification Services will send the operator a completion letter and professional growth transcript. This letter is the only official record DOH accepts as documentation of satisfying the professional growth requirement. Washington Certification Services will also notify DOH that the operator has satisfied the professional growth requirement.

If an operator completes training to satisfy the professional growth requirement by December 31 of the reporting year using Option 1, but fails to provide documentation to Washington Certification Services, the operator's certificate will be temporarily valid for two months (WAC 246-292-090 (5)).

Relevant CEU or college credit earned during the professional growth reporting period may be submitted to Washington Certification Services for consideration until **February 15** of the period in which the operator holds a temporarily valid certificate. If the documentation submitted satisfies the professional growth requirement, DOH will notify the operator that the certificate is renewable.

**If the operator fails to satisfy the professional growth requirement by the deadline, the operator's certificate will not be renewable and cannot be appealed.**



## Revocation and Suspension

---

The Department of Health (DOH) may suspend an operator's certificate for up to one year or revoke an operator's certificate for up to five years in any of the following circumstances (WAC 246-292-100):

- The operator obtains a certificate by fraud or deceit.
- The operator performs an act of gross negligence in the operation of a purification plant or distribution system.
- The operator intentionally violates the requirements of state drinking water laws, DOH statutes, rules, or orders.

Except in a case of fraud, deceit, or gross negligence, DOH may not revoke or suspend a certificate until the Waterworks Operator Certification Program notifies the operator in writing of the violation, and provides an opportunity for the operator to correct the violation.

A revocation or suspension action brought under this section will follow state drinking water laws and rules (RCW 43.70.115, RCW 34.05 and WAC 246-10).

A person whose certificate is revoked may not apply for certification until the end of the revocation period.

After the revocation period ends, a person whose certificate was revoked may apply as a new operator (WAC 246-292-070).

To maintain certification during the suspension period, an operator whose certificate is suspended must continue to meet all the renewal requirements (WAC 246-292-090).

## Relevancy Review and Appeal Procedure

---

The Professional Growth Program Manager will review training a:

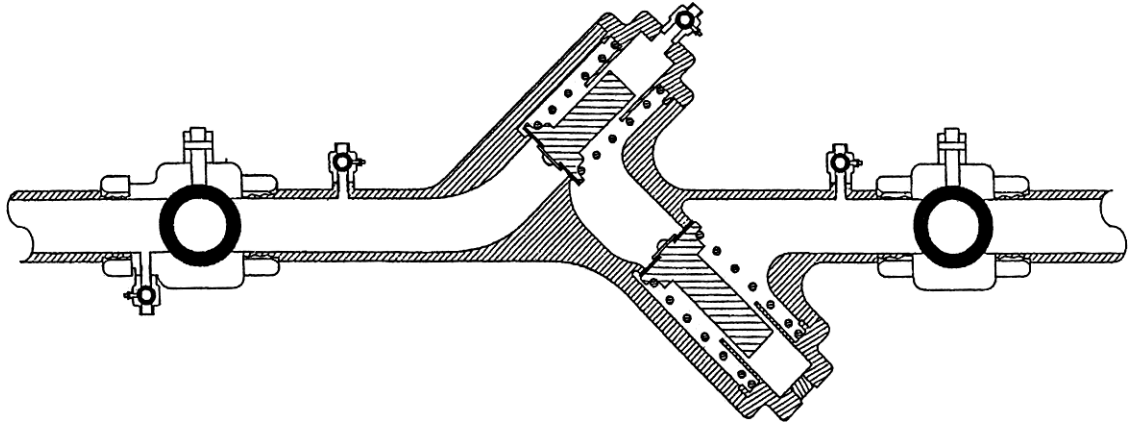
- Course sponsor submits for continuing education unit (CEU) evaluation and assignment.
- Certified operator submits that has already been awarded CEU by the course sponsor.

All training must meet the Department of Health's (DOH) relevancy criteria. DOH will reject any training that does not meet the relevancy criteria.

The Relevancy Subcommittee (Subcommittee) will review all training that may not meet DOH relevancy criteria. The Subcommittee consists of three members of the Waterworks Operator Certification Advisory Committee (Committee) and one person representing the Office of Drinking Water.

The Professional Growth Program Manager will provide the course information to the Waterworks Certification Program Manager who will distribute it to the Subcommittee for review and a relevancy determination recommendation. The Subcommittee will give its recommendation to the Waterworks Certification Program Manager within 15 days of receipt of the request. Upon receipt of the Subcommittee's recommendation, the Waterworks Certification Program Manager will notify the Professional Growth Program Manager of DOH's decision. If DOH previously reviewed and denied a topic, the Professional Growth Program Manager will notify the person who submitted the training for evaluation.

If the course is not accepted toward the professional growth requirement, the course sponsor or operator may ask the Waterworks Certification Program Manager for relevancy appeal information.



## **Section 3 Backflow Assembly Testers**

## **Backflow Assembly Tester Certification**

---

Washington Certification Services at Green River Community College (GRCC) in Auburn administers the State of Washington's backflow assembly tester (BAT) certification program and exams through an interagency agreement with Department of Health Office of Drinking Water (DOH). Washington Certification Services follows the rules, policies, and procedures DOH established in cooperation with the Waterworks Operator Certification Advisory Committee.

DOH is directly responsible for oversight of the BAT certification program and for enforcement activities. (See page 46 Backflow Assembly Tester Revocation and Suspension)

### **Americans with Disabilities Act**

Applicants for exam may request special accommodation for a documented disability. Washington Certification Services requires applicants requesting special accommodations to submit the Request for Accommodation forms, which include current documentation of the disability from an individual qualified to assess the disability. The documentation must identify the diagnosis and nature of the disability, the last time the provider saw the applicant, the name of the test used to diagnose the disability, the duration of the condition, and the recommended accommodation. A physician or licensed health care provider appropriate to the disability must provide the documentation on professional letterhead.

If Washington Certification Services allows special exam accommodation, it will set the time and place it considers appropriate to address the applicant's needs.

**You must submit the completed Request for Accommodation forms to Washington Certification Services at least 30 days prior to the exam date.**

For information about the BAT certification program and exams contact:

Washington Certification Services  
Green River Community College  
110 2<sup>nd</sup> Street SW Suite 135  
Auburn, Washington 98001  
253-288-3357 or 877-780-2444

# Backflow Assembly Tester Certification Exam

---

Washington State Department of Health (DOH) requires anyone who inspects, tests, or monitors backflow prevention assemblies to pass the state's backflow assembly tester (BAT) certification exam and hold a valid certificate (WAC 246-290-490).

## Application and Exam Fees

### **You are eligible to apply if:**

- You are not already certified as a BAT in Washington.
- You took a BAT certification exam and received notification in the mail that you did not pass.

No education, experience, or training is required as a prerequisite for taking this exam.

To apply for a BAT certification exam, contact Washington Certification Services for the current schedule, fees, and procedures.

## Reciprocity with Other States

Washington does not have reciprocity with other states' BAT certification programs or exams.

## Certification Exam Criteria

The Washington State backflow assembly tester (BAT) certification exam consists of two types of exams. You must pass both parts of the exam to become a certified BAT in Washington State.

**If you fail either part of the exam, you must reapply, pay all applicable fees, and take both parts of the exam again.**

All exam applicants must provide picture identification (driver license, military identification card, or other government issued identification) prior to taking the exam.

- ***Written Exam***

The written exam consists of 100 multiple-choice questions developed by the Association of Boards of Certification (ABC). Three hours are allowed to complete the closed-book exam. Notes, books, or other reference materials are not permitted during the exam. The passing score for the written exam is 70 percent.

- ***Practical (Hands-On) Exam***

- One hour is allowed to demonstrate competency in testing the following four backflow prevention assemblies using field test procedures approved by Department of Health:
  - Pressure Vacuum Breaker Assembly (PVBA)
  - Spill-Resistant Pressure Vacuum Breaker Assembly (SVBA)
  - Double Check Valve Assembly (DCVA)
  - Reduced Pressure Backflow Assembly (RPBA)

- During the one-hour exam a failure condition may be simulated on the RPBA, DCVA, and PVBA. If a failure condition is simulated, it must be correctly identified and diagnosed. There is no simulated failure condition for the SVBA.
- You will be required to fill out a test report of all four backflow prevention assemblies. They must be complete, accurate, and legible. The test reports may be completed after the 1-hour time limit for the practical exam.

## **Test Procedures**

During the practical exam, applicants will be examined using only the test procedures in the *10<sup>th</sup> Edition of the Manual of Cross Connection Control* published by the University of Southern California Foundation for Cross Connection Control and Hydraulic Research.

The Non-Illustrated Field Test Procedures 10<sup>th</sup> Edition, excerpted from the *Manual of Cross Connection Control 10<sup>th</sup> Edition*, will be available at the exam site.

## **Test Kits**

A five-valve differential pressure test kit will be available for applicant use at the exam site. Applicants may use their own differential pressure test kit if they provide the exam proctor with a current certificate of accuracy or calibration.

## Backflow Assembly Tester Professional Growth Requirement

---

The Waterworks Operator Certification rules require a certified backflow assembly tester (BAT) to demonstrate professional growth by passing the Department of Health's (DOH) BAT professional growth exam during each reporting period (WAC 246-292-090 (4)). Washington Certification Services schedules and administers the BAT professional growth exam.

All certified BATs are assigned a professional growth reporting period based on their original certification date. DOH provides each BAT with a minimum of 3 years to meet the professional growth requirement by passing the BAT professional growth exam. The BAT professional growth exam may be taken at any time during the reporting period dates, but must be passed by the reporting period deadline. Failure to meet the professional growth requirement within the designated timeframe is not eligible for appeal.

### When certified backflow assembly testers must meet their professional growth requirement:

<b>If your original certification date is:</b>	<b>Then you must meet the professional growth requirement between:</b>
Before 1/1/2010	1/1/2013 and 12/31/2015 and in each 3-year reporting period thereafter.
1/1/2010 - 12/31/2012	Your original certification date and 12/31/2015 and in each 3-year reporting period thereafter.
1/1/2013 - 12/31/2015	Your original certification date and 12/31/2018 and in each 3-year reporting period thereafter.

# Backflow Assembly Tester Professional Growth Exam

---

## Application and Exam Fees

### **You are eligible to apply if:**

- You are certified as a BAT in Washington.
- You have not taken a professional growth exam in the current reporting period.
- You took a professional growth exam in the current reporting period and received notification in the mail that you did not pass.

No education, experience, or training is required as a prerequisite for taking this exam.

To apply for a BAT professional growth exam, contact Washington Certification Services for the current schedule, fees and procedures.

## Reciprocity with Other States

Washington does not have reciprocity with other states' BAT certification programs or exams.

## Professional Growth Exam Criteria

The Washington State backflow assembly tester (BAT) professional growth exam is a practical (hands-on) exam. If you fail the exam, you must reapply, pay all applicable fees, and take the exam again.

All exam applicants must provide picture identification (driver license, military identification card, or other government issued identification) prior to taking the exam.

- One hour is allowed to demonstrate competency in testing the following four backflow prevention assemblies using field test procedures approved by Department of Health:
  - Pressure Vacuum Breaker Assembly (PVBA)
  - Spill-Resistant Pressure Vacuum Breaker Assembly (SVBA)
  - Double Check Valve Assembly (DCVA)
  - Reduced Pressure Backflow Assembly (RPBA)
- During the one-hour exam a failure condition may be simulated on the RPBA, DCVA, and PVBA. If a failure condition is simulated, it must be correctly identified and diagnosed. There is no simulated failure condition for the SVBA.



## **Test Procedures**

During the practical exam, applicants will be examined using only the test procedures in the *10<sup>th</sup> Edition of the Manual of Cross Connection Control* published by the University of Southern California Foundation for Cross Connection Control and Hydraulic Research.

The Non-Illustrated Field Test Procedures 10<sup>th</sup> Edition, excerpted from the Manual of Cross Connection Control 10<sup>th</sup> Edition, will be available at the exam site.

## **Test Kits**

A five-valve differential pressure test kit will be available for applicant use at the exam site.

Applicants may use their own differential pressure test kit if they provide the exam proctor with a current certificate of accuracy or calibration.

# Backflow Assembly Tester Certification Renewal Process

---

All certified backflow assembly testers (BAT) must renew their certificates January 1 of each year.

## Renewal Notices

Washington Certification Services at Green River Community College will mail the first renewal notice to the ***BAT's home mailing address*** the second week of November. If payment is not postmarked by the deadline listed on the first renewal notice, a second and final renewal notice will be mailed.

A late fee will be assessed to BATs failing to submit the required renewal fee within the period specified on the first renewal notice.

Any additional fees incurred by Green River Community College (GRCC) for checks returned for non-sufficient funds (NSF) will be charged to the backflow assembly tester. All fees must be paid in full by the final renewal deadline.

**Failure to pay the renewal fee by the final deadline or meet the professional growth requirement within the designated timeframe is not eligible for appeal.**

## Certificate Renewal

Washington Certification Services will renew the BAT certificate annually when it receives the renewal fee payment by the specified deadline. A certification validation card will be issued for the renewal year.

**During the deadline year of a professional growth reporting period, a renewal will not be mailed until the BAT meets the professional growth requirement.**

Washington Certification Services will notify BATs failing to renew their certificate that it is temporarily valid for two months beginning January 1. A certificate not renewed during the two-month period will become invalid. Washington Certification Services will send written notice informing the BAT the certificate is no longer valid.

BATs failing to renew their certification may reapply for certification and must meet the requirements of a new applicant (WAC 246-292-090).

## Address Changes

BATs must keep Washington Certification Services informed of their current home mailing address. Address changes must be reported in writing. **Failure to notify Washington Certification Services of an address change does not constitute a reasonable excuse for waiver of the late fee assessment, failure to renew a certificate, or failure to demonstrate professional growth.**

## **Backflow Assembly Tester Revocation and Suspension**

---

The Department of Health (DOH) may suspend a backflow assembly tester's (BAT) certificate for up to 1 year or revoke a BAT's certificate for up to 5 years in any of the following circumstances(WAC 246-292-100):

- The BAT obtains a certificate by fraud or deceit.
- The BAT performs an act of gross negligence in the operation of a purification plant or distribution system.
- The BAT intentionally violates the requirements of state drinking water laws, DOH statutes, rules, or orders.

Except in a case of fraud, deceit, or gross negligence, DOH may not revoke or suspend a certificate until the Waterworks Operator Certification Program notifies the BAT of the violation in writing and provides an opportunity for the BAT to correct the violation.

A revocation or suspension action brought under this section will follow state drinking water laws and rules (RCW 43.70.115, RCW 34.05, and WAC 246-10).

A person whose certificate is revoked may not apply for certification until the end of the revocation period.

After the revocation period ends, a person whose certificate was revoked may apply as a new BAT (WAC 246-292-070).

To maintain certification during the suspension period, a BAT whose certificate is suspended must continue to meet all renewal requirements (WAC 246-292-090).

## **Backflow Assembly Tester Certification Written Exam Subject Areas**

---

The written exam consists of 100 multiple-choice questions. Hand-held numeric calculators may be used.

Below is the exam description.

Air Gap
Atmospheric Vacuum Breaker
Backflow Prevention Concepts
Cross Connection Concepts
Double Check Valve Assembly
Field Testing
Public Health
Pressure Vacuum Breaker
Regulations
Reduced Pressure Assembly
Test Equipment

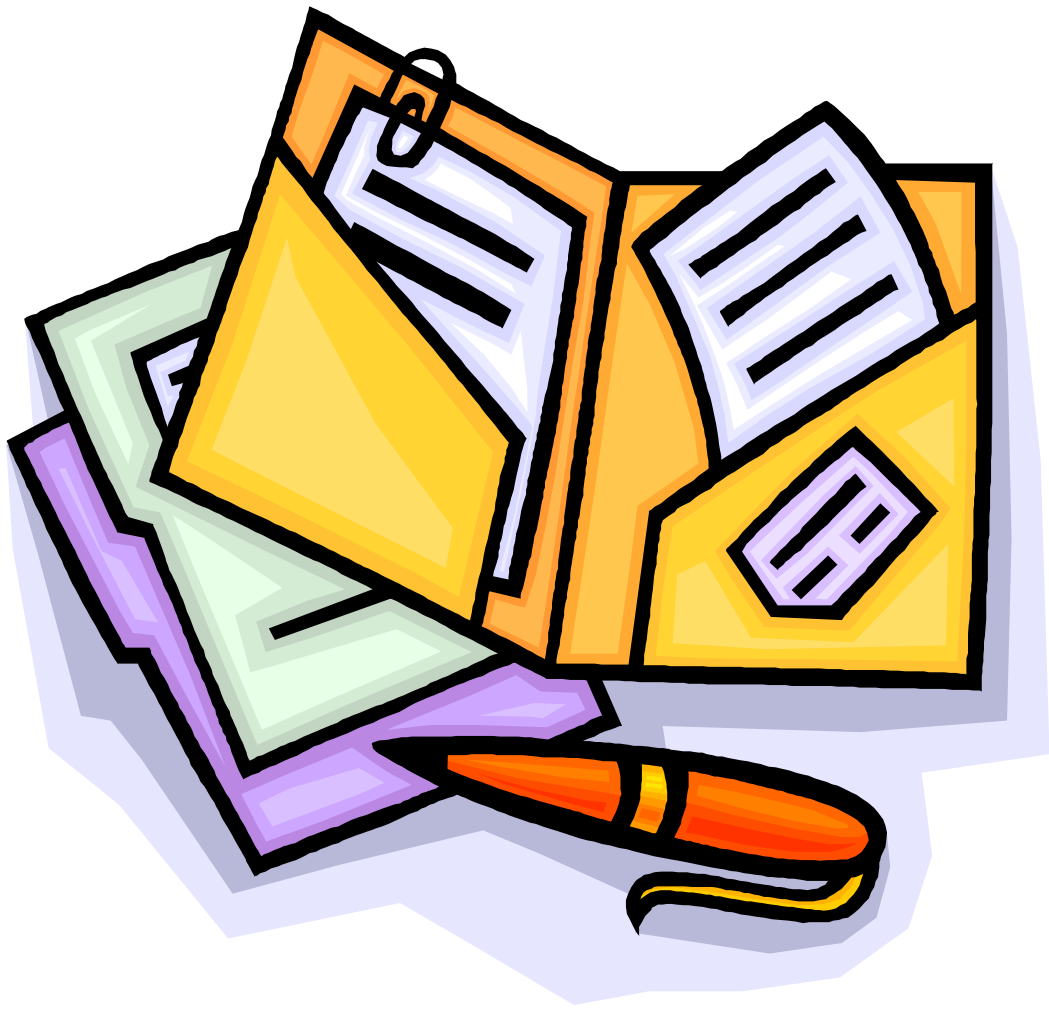
The passing score for this exam is 70 percent.

## Backflow Assembly Tester Exam Reference Materials

<i>PNWS-AWWA Cross Connection Control Manual, Sixth Edition</i>	Pacific NW Section of AWWA PO Box 2050 Clackamas, OR 97051-2050 Phone Number: 503-655-4075 Website: <a href="http://www.pnws-awwa.org">http://www.pnws-awwa.org</a>
<i>Backflow Prevention Assemblies Field Test Procedure Approved for Use in Washington State</i>	Washington Certification Services 110 2 <sup>nd</sup> Street SW Suite 135 Auburn, WA 98001 Phone Number: 877-780-2444
<i>Backflow Prevention Assemblies Approved for Installation in Washington State</i>	Constituent Services Section Department of Health, Office of Drinking Water PO Box 47822 Olympia, WA 98504-7822 Phone Number: 800-521-0323
<i>Manual of Cross Connection Control, 10<sup>th</sup> Edition</i>	Foundation for Cross Connection Control and Hydraulic Research University of Southern California KAP-200 University Park MC-2531 Los Angeles, CA 90089-2531 Phone Number: 213-740-2032 Website: <a href="http://www.usc.edu/">http://www.usc.edu/</a>
<i>WAC 246-290-490 Cross Connection Control – extracted from WAC 246-290 Group A Drinking Water Regulations</i>	Water Quality Section Department of Health, Office of Drinking Water PO Box 47822 Olympia, WA 98504-7822 Phone Number: 360-236-3133 Website: <a href="http://www.doh.wa.gov/ehp/dw/">http://www.doh.wa.gov/ehp/dw/</a>
<i>Journeyman Plumbers Certification Law RCW 18.106</i>	Plumbers Certification Department of Labor and Industries PO Box 44470 Olympia, WA 98504-4470 Phone Number: 360-902-5207 Website: <a href="http://www.lni.wa.gov/tradeslicensing/plumbing/">http://www.lni.wa.gov/tradeslicensing/plumbing/</a>

## **Backflow Assembly Tester Professional Growth Exam Reference Materials**

<i>Backflow Prevention Assemblies Approved for Installation in Washington State</i>	Constituent Services Section Department of Health, Office of Drinking Water PO Box 47822 Olympia, WA 98504-7822 Phone Number: 800-521-0323
<i>Backflow Prevention Assemblies Field Test Procedures Approved for Use in Washington State</i>	Washington Certification Services 110 2 <sup>nd</sup> Street Suite 135 Auburn, WA 98001 Phone Number: 877-780-2444



# Appendices

## Appendix A Water Distribution Specialist (WDS) Exam Information

This exam consists of 50 multiple-choice questions. Hand-held numeric calculators may be used. The formulas and conversion tables are in each exam booklet and *Appendix I* of this publication. Below is the exam description.

<b>Operate system</b>
System Design
• Flushing program
• System layout
• Assess system demand
System Inspection
• Cross connection surveys/control
• Well inspection
Chlorine Disinfection
• Monitor, evaluate, and adjust disinfection process
<b>Water Quality Parameters and Sampling</b>
• Chlorine demand/residual/dosage
• Coliform
<b>Operate equipment</b>
• Chlorinators
• Hydrants
• Pumps
• Valves
<b>Install, Maintain and Evaluate Equipment</b>
Install and maintain equipment
• Pipe repair
• Water mains
• Service connections
• Storage tanks
Evaluate operation of equipment
• Read meters
• Troubleshoot electrical equipment
<b>Perform Safety Procedures</b>
• Chemical handling
• Confined space entry
• Fire safety
• Lock-out and tag-out
<b>Perform Administrative and Compliance Duties</b>
Administrative and Security
• Respond to complaints
• Develop operation and maintenance plan
• Record and evaluate data
Comply with Drinking Water Regulations
• Subpart B-Maximum contaminant levels



## Appendix A (continued)

• Subpart C-Monitoring and analytical requirements
• Subpart D-Reporting and recordkeeping
• Subpart Q-Public notification of drinking water violations
<b>Operate system</b>
Add liquid disinfectants
Monitor, evaluate, and adjust chlorine disinfection
Inspect and maintain flow measurement
Inspect, maintain, and repair wells
<b>Evaluate characteristics of source water</b>
Bacteriological
Biological
Chemical
<b>Collect, perform and interpret laboratory analyses</b>
Chlorine demand
Chlorine residual
Microbiological
<b>Operate equipment</b>
Chemical feeders
Instrumentation
Pumps
<b>Evaluate operation of equipment</b>
Check speed of equipment
Perform preventive maintenance on chemical feeders
Read meters
Read pressure gauges
<b>Perform administrative duties</b>
Administer safety program
Establish record keeping systems for facility operation
Record information relating to facility performance
<b>Establish safety plans and apply safety procedures</b>
Chemical hazard communication
Confined space entry
Electrical grounding
General safety and health
Lock-out and tag-out
Personal protective equipment
Respiratory protection

The passing score for this exam is 70 percent.

For more information go to [http://www.abccert.org/testing\\_services/need\\_to\\_know\\_criteria.asp](http://www.abccert.org/testing_services/need_to_know_criteria.asp)

### **Exam Reference Materials**

See Appendix C

## Appendix B Water Distribution Manager (WDM) Exam Information

This exam consists of 100 questions, depending on the level of the exam. An “X” indicates that there will be one or more questions in that area on the exam. The total number of questions and the number of math questions are listed at the bottom of the table. The formulas and conversion table are in each exam booklet and *Appendix I* of this publication.

	Exam Level			
	WDM IT/1	WDM 2	WDM 3	WDM 4
<b>System Design</b>				
Assess system demand	X	X	X	X
Design thrust blocks	X	X	X	X
Flushing program	X	X	X	X
System layout	X	X	X	X
Perform pressure readings	X	X	X	X
Read blueprints, readings, and maps	X	X	X	X
Select type of pipes	X		X	X
Size mains		X	X	X
<b>National Primary Drinking Water Regulations</b>				
Subpart A - General definitions	X	X	X	
Subpart B - Maximum contaminant levels			X	X
Subpart C - Monitoring and analytical requirements	X	X	X	X
Subpart D - Reporting and record keeping	X	X		
Subpart I - Control of lead and copper	X	X	X	X
Subpart Q - Public notification of drinking water violations	X	X	X	X
<b>Monitor, Evaluate and Adjust Disinfection</b>				
Chlorine disinfection	X	X	X	X
<b>Water Quality Parameters and Sampling</b>				
Chlorine demand/residual/dosage	X	X	X	X
Coliforms	X	X	X	X
Conductivity			X	
Iron/manganese	X		X	
Lead/copper			X	X
pH	X	X		X
Temperature		X	X	X
Turbidity		X	X	X
General	X	X	X	X
<b>System Inspection</b>				
Cross connection surveys/control	X	X	X	X
Sanitary surveys	X	X	X	X
Well inspection	X	X	X	X

## Appendix B (continued)

	WDM IT/1	WDM 2	WDM 3	WDM 4
<b>Install Equipment</b>				
Backflow prevention devices	X	X	X	X
Hydrants			X	
Meters	X	X	X	X
Piping and fitting	X	X	X	X
Service connections	X	X	X	X
Taps	X		X	
Water mains	X	X	X	X
<b>Operate Equipment</b>				
Cathodic protection devices		X		
Centrifugal pumps	X	X	X	X
Chemical feeders		X		X
Chlorinators		X		X
Electrical motors	X		X	X
Hydrants	X	X	X	X
Instrumentation			X	X
Leak correlators/detectors			X	X
Positive-displacement pumps	X			
SCADA system			X	
Tapping equipment			X	X
Valves	X	X	X	X
General	X	X	X	X
<b>Evaluate and Maintain Equipment</b>				
Backflow prevention devices	X	X		
Cathodic protection devices		X	X	X
Chemical feeders			X	
Chlorinators			X	X
Corrosion control			X	X
Electric motors		X	X	
Hydrants		X		
Joints	X		X	
Leak detection				
Meters	X			
Pipe repair	X	X	X	X
Pressure sensors		X	X	X
Pumps	X	X		X
Water storage facility	X	X	X	X

## Appendix B (continued)

	WDM IT/1	WDM 2	WDM 3	WDM 4
<b>Perform Security, Safety and Administrative Duties</b>				
<b>Perform security and safety procedures</b>				
Chemical handling	X		X	X
Confined space entry	X	X	X	X
Contamination			X	X
Fire safety	X	X	X	X
Lock-out/tag-out	X	X	X	
Personal protective equipment			X	
Trenching		X	X	X
<b>Perform administrative procedures such as</b>				
Administer compliance, emergency preparedness and safety program	X	X	X	X
Develop budget	X	X	X	X
Develop operation and maintenance plan	X	X	X	X
Plan and organize work activities			X	X
Record and evaluate data	X			X
Respond to complaints		X	X	X
<b>Total Number of Exam Questions</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

The passing score for these exams is 70 percent.

For more information go to [http://www.abccert.org/testing\\_services/need\\_to\\_know\\_criteria.asp](http://www.abccert.org/testing_services/need_to_know_criteria.asp)

### **Exam Reference Materials**

See Appendix C

## Appendix C    Water Distribution Specialist and Water Distribution Manager Exam Reference Materials

---

Below are approved reference sources for the ABC Water Distribution Specialist (WDS) and Water Distribution Manager (WDM) exams. Operators should use the latest edition of these reference sources to prepare for the exam.

### **American Water Works Association (AWWA)**

- *Water Transmission and Distribution*
- *Water Distribution Operator Training Handbook*
- *Basic Science Concepts and Applications*
- *Water System Security, A Field Guide*
- *Water Quality*

To order, contact:

American Water Works Association

6666 West Quincy Avenue

Denver, CO 80235

Website: <http://www.awwa.org/>

Phone: 800-926-7337

Fax: 303-347-0804

Email: [custsvc@awwa.org](mailto:custsvc@awwa.org)

### **Association of State Drinking Water Administrators (ASDWA) and National Rural Water Association (NRWA)**

- *Security Vulnerability Self Assessment Guide for Small Drinking Water Systems*

To order, contact:

ASDWA

1401 Wilson Blvd Suite 1225

Arlington VA 22209

Website: <http://www.asdwa.org/> (available online in PDF format; select “Program Areas,” then “Security,” then “Training and Tools”)

Phone: 703-812-9505

Fax: 703-812-9506

Email: [info@asdwa.org](mailto:info@asdwa.org)

## Appendix C (continued)

### **California State University, Sacramento (CSUS) Foundation, Office of Water Programs**

- *Water Distribution System Operation and Maintenance*
- *Small Water System Operation and Maintenance*
- *Water Treatment Plant Operation, Volumes I and II*
- *Utility Management*
- *Manage for Success*

To order, contact:

Office of Water Programs  
California State University Sacramento  
6000 J Street  
Sacramento, CA 95819-6025  
Website: <http://www.owp.csus.edu/>  
Phone: 916-278-6142  
Fax: 916-278-5959  
Email: [wateroffice@owp.csus.edu](mailto:wateroffice@owp.csus.edu)

### **Department of Health, Office of Drinking Water**

- *Water Works Certification, chapter 246-292 WAC*
- *Group A Public Water Systems, chapter 246-290 WAC*

To order, contact:

Department of Health, Office of Drinking Water  
PO Box 47822  
Olympia, WA 98504  
Website: <http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater.aspx>  
Phone: 360-236-3100

## Appendix D Basic Treatment Operator (BTO) Exam Information

---

This exam consists of 75 multiple-choice questions. Hand-held numeric calculators may be used. The formulas and conversion tables are in each exam booklet and *Appendix I* of this publication.

<b>Evaluate characteristics of source water</b>
Biological
Physical
<b>Collect, perform, and interpret laboratory analyses</b>
Chlorine residual
Giardia lamblia
pH
<b>Monitor, evaluate, adjust system</b>
Cartridge/bag filters
Chlorine disinfection
Slow sand filters
Flow measurement
<b>Evaluate operation of equipment</b>
Read flow and hour meters
Read pressure gauges
<b>Operate equipment</b>
Chemical feeders
Chlorinators
Manual controlled valves
Pumps and motors
<b>Perform maintenance</b>
Pumps and motors
<b>Perform safety procedures</b>
Confined space entry
Electrical
Lock-out/tag-out
Trenching and shoring
<b>Establish emergency plan and respond to emergencies</b>
Equipment failure
Regulation violation
System upset (disinfection failure, contamination, power outage, etc.)
<b>Perform administrative duties</b>
Promote public relations
Record information for finances, maintenance, system operation, water quality compliance (pH, chlorine residual, etc.)

The passing score for this exam is 70 percent.

### Exam Reference Materials

See Appendix F

## Appendix E Water Treatment Plant Operator (WTPO) Exam Information

This exam consists of 100 questions, depending on the level of the exam. An “X” indicates there will be one or more questions in that area on the exam. The total number of questions and the number of math questions are at the bottom of the table. The formulas and conversion table are in each exam booklet and *Appendix I* of this publication.

	Exam Level			
	WTPO IT/1	WTPO 2	WTPO 3	WTPO 4
<b>Monitor, Evaluate and Adjust Treatment Processes</b>				
Source Water Treatment (algae control, chemical treatment)				X
Intake Structure	X	X	X	X
Chemical Treatment/Addition (fluoridation, chlorine disinfection, ozone disinfection, UV disinfection, pH adjustment, corrosion control)	X	X	X	X
Coagulation & Flocculation (chemical coagulants, rapid mix units, flocculation tanks)		X	X	X
Clarification/Sedimentation (sedimentation basins, up-flow solids-contact clarification, inclined-plate sedimentation, tube sedimentation)		X	X	X
Filtration (gravity/rapid sand, membrane, cartridge, slow sand, direct, pressure or greensand, diatomaceous earth)		X	X	X
Other Treatment Processes (aeration, ion exchange softening, iron and manganese removal, lime-soda ash softening, gac, pac, aids)		X	X	X
Residuals Disposal		X	X	X
<b>National Primary Drinking Water Regulations</b>				
Subpart A – General definitions	X	X	X	X
Subpart B – Maximum contaminant levels			X	X
Subpart C – Monitoring and analytical requirements	X	X	X	X
Subpart E – Special regulations			X	
Subpart G – National revised primary drinking water regulations	X	X		X
Subpart H – Filtration and disinfection		X	X	X
Subpart I – Control of lead and copper	X	X	X	X
Subpart J – Use of non-centralized treatment devices	X			
Subpart L – Disinfection residuals, disinfection byproducts, and disinfection byproduct precursors		X	X	X
Subpart O – Consumer confidence reports			X	
Subpart P – Enhanced filtration and disinfection		X	X	X
Subpart Q – Public notification of drinking water violations	X	X		X



## Appendix E (continued)

	WTPO IT/1	WTPO 2	WTPO 3	WTPO 4
<b>Collect Samples and Interpret Analysis</b>				
Alkalinity			X	
Chlorine demand		X		X
Chlorine residual	X	X	X	X
Disinfectant by-products (THM)			X	X
Dissolved oxygen			X	X
Hardness			X	
Inorganic (heavy metal) chemical			X	
Iron/manganese				X
Jar test			X	
Microbiological	X	X	X	X
pH	X			X
Sampling/Lab equipment	X		X	X
Turbidity	X	X	X	X
<b>Perform Process Control Laboratory Analysis</b>				
Alkalinity		X	X	X
Carbon Dioxide				
Chlorine residual	X	X	X	X
Fluoride	X		X	
Hardness		X	X	X
Iron and Manganese		X		
Jar test			X	X
Microbiological		X	X	X
pH	X	X		
Sampling/Lab equipment	X	X	X	X
Temperature		X	X	X
Turbidity		X	X	X
<b>Evaluate Characteristics of Source Water</b>				
Bacteriological	X	X	X	X
Biological			X	X
Chemical	X		X	X
Physical	X	X	X	X
<b>Operate Equipment</b>				
Chemical feeders	X	X	X	X
Hydraulic equipment		X		
Prime movers/drivers	X	X		X
Valves	X	X	X	X
Water pumps	X	X	X	X

## Appendix E (continued)

	WTPO IT/1	WTPO 2	WTPO 3	WTPO 4
<b>Evaluate and Maintain Equipment</b>				
<b>Evaluate operation of equipment</b>				
Inspect equipment for abnormal conditions	X	X	X	X
Read pressure gauges	X	X	X	X
<b>Perform Maintenance</b>		X		
Blowers, compressors, and pneumatics			X	X
Chemical feeders	X			X
Instrumentation		X	X	X
Pipes	X	X	X	X
Prime movers/drivers	X	X	X	X
Valves	X	X		
Water pumps	X	X	X	X
<b>Perform Security, Safety and Administrative Duties</b>				
<b>Perform security and safety procedures</b>				
Chemical handling	X	X	X	X
Confined space entry	X	X	X	X
Lock-out/tag-out	X	X		
Personal protective equipment		X		
Spill response	X	X		
<b>Perform administrative procedures such as</b>				
Administer compliance, emergency preparedness and safety program	X	X	X	X
Record and evaluate data	X			
Complaint response	X			
Develop O&M plan	X			
Develop budget		X	X	X
Total Number of Exam Questions	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

The passing score for these exams is 70 percent.

For more information go to [http://www.abccert.org/testing\\_services/need\\_to\\_know\\_criteria.asp](http://www.abccert.org/testing_services/need_to_know_criteria.asp)

### **Exam Reference Materials**

See Appendix F

## Appendix F      **Basic Treatment Operator and Water Treatment Operator Exam Reference Materials**

---

Below are approved references for the ABC Basic Treatment Operator and Water Treatment Plant Operator exams. Operators should use the latest edition of these reference sources to prepare for the exam.

### **American Water Works Association (AWWA)**

Principles and Practices of Water

Supply Operations Series:

- *Water Sources*
- *Water Treatment*
- *Water Transmission and Distribution*
- *Water Quality*
- *Basic Science Concepts and Applications*

Other AWWA References:

- *Water Quality and Treatment*
- *Water System Security, A Field Guide*

To order, contact:      American Water Works Association  
6666 W Quincy Avenue  
Denver CO 80235  
Website: <http://www.awwa.org/>  
Phone: 800-926-7337  
Fax: 303-347-0804  
Email: [custsvc@awwa.org](mailto:custsvc@awwa.org)

### **Association of State Drinking Water Administrators (ASDWA) and National Rural Water Association (NRWA)**

- *Security Vulnerability Self Assessment Guide for Small Drinking Water Systems*

To order, contact:      ASDWA  
1401 Wilson Boulevard Ste 1225  
Arlington, VA 22019  
Website: <http://www.asdwa.org> (available online in PDF format; select Program Areas," then "Security," then Training and Tools")  
Phone: 703-812-9505  
Fax: 703-812-9506  
Email: [info@asdwa.org](mailto:info@asdwa.org)

## Appendix F (continued)

### California State University, Sacramento (CSUS) Foundation, Office of Water Programs

- *Water Treatment Plant Operation, Volumes I and II*
- *Manage for Success*

To Order, contact: Office of Water Programs  
California State University, Sacramento  
6000 J Street  
Sacramento, CA 95819-6025  
Website: <http://www.owp.csus.edu>  
Phone: 916-278-6142  
Fax: 916-278-5959  
Email: [wateroffice@owp.csus.edu](mailto:wateroffice@owp.csus.edu)

### Department of Health, Office of Drinking Water

- *Waterworks Operator Certification, chapter 246-292 WAC*
- *Group A Public Water Systems, chapter 246-290 WAC*

To order, contact: Department of Health, Office of Drinking Water  
P.O. Box 47822  
Olympia, WA 98504  
Website:  
<http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater.aspx>  
Phone: 800-521-0323

## Appendix G Cross-Connection Control Specialist (CCS) Exam Information

---

This exam consists of 100 multiple-choice questions. Hand-held numeric calculators may be used. Formulas and conversion factors are in each exam booklet and *Appendix I* of this publication. Below is the exam description.

Applicability of Regulations
Approved Backflow Preventers
Inspection and Testing Requirement
Causes of Backpressure
Causes of Backsiphonage
Certification Requirements
Categories of Contaminants
General Definitions
Regulatory Definitions
Installation Requirements
Levels of Protection
Minimum CCC Program Elements
General Program Requirements
Purpose of Regulations
Regulatory Responsibilities
Backflow Preventer Requirement
Risk Assessment
Backflow Preventer Selection
Testing of Assemblies

The passing score for this exam is 70 percent.

### **Exam Reference Materials**

See Appendix H.

## **Appendix H     Cross Connection Control Specialist (CCS) Exam Reference Materials**

---

Here are approved references for the ABC Cross-Connection Control Specialist (CCS) exam.

- **Manual of Cross-Connection Control**, 10<sup>th</sup> Edition, Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, KAP-200 University Park MC-2531, Los Angeles, California 90089-2531, Phone: (213) 740-2032.
- **Recommended Practice for Backflow Prevention and Cross-Connection Control**, AWWA Manual M14, American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235, Phone: (800) 926-7337.
- **Cross-Connection Control Manual**, (WH-550) USEPA, Water Resource Center (RC4100), Room 2615, 401 M Street SW Washington, DC 20460, Phone: (202) 260-7786.
- **Cross Connection Control Manual, Accepted Procedure and Practice Handbook**, Pacific Northwest Section-AWWA, PO Box 2050, Clackamas, OR 97015. Phone: (877) 767-2992.

## Appendix I      ABC Formula and Conversion Table for Water Treatment and Distribution Exams

---

$$\text{Alkalinity, as mg CaCO}_3/\text{L} = \frac{(\text{Titrant Volume, mL}) (\text{Acid Normality}) (50,000)}{\text{Sample Volume, mL}}$$

$$\text{Amps} = \text{Volts/Ohms}$$

$$\text{Area of Circle} = (\pi/4) (\text{Diameter}^2) \text{ or } (\pi)(\text{Radius}^2)$$

$$\text{Area of Cone (lateral area)} = (\pi) (\text{Radius}) \sqrt{\text{Radius}^2 + \text{Height}^2}$$

$$\text{Area of Cone (total surface area)} = (\pi) (\text{Radius}) (\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})$$

$$\text{Area of Cylinder (total outside surface area)} = [\text{Surface Area of End \#1}] + [\text{Surface Area of End \#2}] + [(\pi)(\text{Diameter})(\text{Height or Depth})]$$

$$\text{Area of Rectangle} = (\text{Length}) (\text{Width})$$

$$\text{Area of a Right Triangle} = \frac{(\text{Base}) (\text{Height})}{2}$$

$$\text{Average (arithmetic mean)} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

$$\text{Average (geometric mean)} = [(X_1)(X_2)(X_3)(X_4)(X_n)]^{1/n} \text{ The } n\text{th root of the product of } n \text{ numbers}$$

$$\text{Chemical Feed Pump Setting, \% Stroke} = \frac{(\text{Desired Flow}) (100\%)}{\text{Maximum Flow}}$$

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(\text{Flow, MGD}) (\text{Dose, mg/L}) (3.785 \text{ L/gal}) (1,000,000 \text{ gal/MG})}{(\text{Liquid, mg/mL}) (24 \text{ hr/day}) (60 \text{ min/hr})}$$

$$\text{Circumference of Circle} = (\pi) (\text{Diameter})$$

$$\text{Composite Sample Single Portion} = \frac{(\text{Instantaneous Flow}) (\text{Total Sample Volume})}{(\text{Number of Portions}) (\text{Average Flow})}$$

$$\text{Degrees Celsius} = (\text{Degrees Fahrenheit} - 32) (5/9) \text{ or } \frac{(^{\circ}\text{F} - 32)}{1.8}$$

$$\text{Degrees Fahrenheit} = (\text{Degrees Celsius}) (9/5) + 32 \text{ or } (\text{Degrees Celsius}) (1.8) + 32$$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

$$\text{Electromotive Force (E.M.F), volts} = (\text{Current, amps}) (\text{Resistance, ohms}) \text{ or } E = IR$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34 \text{ lbs/gal})}{(\text{Purity, decimal percentage})}$$

$$\text{Feed Rate, gal/min (Fluoride Saturator)} = \frac{(\text{Plant capacity, gal/min})(\text{Dosage, mg/L})}{(18,000 \text{ mg/L})}$$

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(\text{Backwash Rate, GPM/sq ft})(12 \text{ in/ft})}{(7.48 \text{ gal/cu ft})}$$

$$\text{Filter Drop Test Velocity, ft/min} = \frac{\text{Water Drop, ft}}{\text{Time of Drop, min}}$$

$$\text{Filter Flow Rate or Backwash Rate, gpm/sq ft} = \frac{\text{Flow, gpm}}{\text{Filter Area, sq ft}}$$

$$\text{Filter Yield, lbs/hr/sq ft} = \frac{(\text{Solids Loading, lbs/day})(\text{Recovery, \% / 100\%})}{(\text{Filter operation, hr/day})(\text{Area, sq ft})}$$

$$\text{Flow Rate, cfs} = (\text{Area, sq ft})(\text{Velocity, ft/sec}) \text{ or } Q = AV \quad \text{where: } Q = \text{flow rate, } A = \text{area, } V = \text{velocity}$$

$$\text{Force, pounds} = (\text{Pressure, psi})(\text{Area, sq in})$$

$$\text{Gallons/Capita/Day} = \frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$$

$$\text{Hardness, as mg CaCO}_3\text{/L} = \frac{(\text{Titration Volume, mL})(1,000)}{\text{Sample Volume, mL}} \quad \text{Only when the titration factor is 1.00 of EDTA}$$

$$\text{Horsepower, Brake (bhp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Decimal Pump Efficiency})}$$

$$\text{Horsepower, Motor (mhp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Decimal Pump Efficiency})(\text{Decimal Motor Efficiency})}$$

$$\text{Horsepower, Water (whp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{3,960}$$

$$\text{Hydraulic Loading Rate} = \frac{\text{Total Flow Applied}}{\text{Area}}$$

$$\text{Hypochlorite Strength, \%} = \frac{(\text{Chlorine Required, lbs})(100)}{(\text{Hypochlorite Solution Needed, gal})(8.34 \text{ lbs/gal})}$$

$$\text{Leakage, gpd} = \frac{\text{Volume, gallons}}{\text{Time, days}}$$

$$\text{Mass, lbs/day} = (\text{Flow, MGD})(\text{Concentration, mg/L})(8.34 \text{ lbs/gal})$$



$$\text{Mass, lbs} = (\text{Volume, MG})(\text{Concentration, mg/L})(8.34 \text{ lbs/gal})$$

$$\text{Milliequivalent} = (\text{mL})(\text{Normality})$$

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

$$\text{Normality} = \frac{\text{Number of Equivalent Weights of Solute}}{\text{Liters of Solution}}$$

$$\text{Number of Equivalent Weights} = \frac{\text{Total Weight}}{\text{Equivalent Weight}}$$

$$\text{Number of Moles} = \frac{\text{Total Weight}}{\text{Molecular Weight}}$$

$$\text{Reduction in Flow, \%} = \frac{(\text{Original Flow} - \text{Reduced Flow})(100\%)}{\text{Original Flow}}$$

$$\text{Removal, \%} = \frac{(\text{In} - \text{Out})(100)}{\text{In}}$$

$$\text{Slope, \%} = \frac{\text{Drop or Rise}}{\text{Distance}} \times 100$$

$$\text{Solids, mg/L} = \frac{(\text{Dry Solids, grams})(1,000,000)}{\text{Sample Volume, mL}}$$

$$\text{Solids Concentration, mg/L} = \frac{\text{Weight, mg}}{\text{Volume, L}}$$

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

$$\text{Surface Loading Rate, gpd/sq ft} = \frac{\text{Flow, gpd}}{\text{Area, sq ft}}$$

$$\text{Three Normal Equation} = (N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3), \text{ where } V_1 + V_2 = V_3$$

$$\text{Two Normal Equation} = N_1 \times V_1 = N_2 \times V_2, \text{ where } N = \text{normality, } V = \text{volume or flow}$$

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate cu ft / sec}}{\text{Area, sq ft}} \text{ or } \frac{\text{Distance, ft}}{\text{Time, sec}}$$

$$\text{Volume of Cone} = (1/3)(\pi/4)(\text{Diameter}^2)(\text{Height})$$

$$\text{Volume of Cylinder} = (\pi/4)(\text{Diameter}^2)(\text{Height})$$

$$\text{Volume of Rectangular Tank} = (\text{Length})(\text{Width})(\text{Height})$$

$$\text{Watts (AC circuit)} = (\text{Volts})(\text{Amps})(\text{Power Factor})$$

Watts (DC circuit) = (Volts) (Amps)

$$\text{Weir Overflow Rate, gpd/ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{\text{Water Horsepower, HP}}{\text{Power Input, HP or Motor HP}} \times 100$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{(\text{Flow, gpm}) (\text{Total Dynamic Head, ft}) (0.746 \text{ kw/hp}) (100)}{(3,960) (\text{Electrical Demand, kilowatts})}$$

---

### Alkalinity Relationships:

Result of Titration	Alkalinity, mg/L as CaCO <sub>3</sub>		
	Hydroxide Alkalinity as CaCO <sub>3</sub>	Carbonate Alkalinity as CaCO <sub>3</sub>	Bicarbonate Concentration as CaCO <sub>3</sub>
P = 0	0	0	T
P < ½T	0	2P	T – 2P
P = ½T	0	2P	0
P > ½T	2P – T	2(T – P)	0
P = T	T	0	0

\*Key: P – phenolphthalein alkalinity; T – total alkalinity

---

### Conversion Factors:

1 acre = 43,560 square feet  
 1 acre foot = 326,000 gallons  
 1 cubic foot = 7.48 gallons  
 1 cubic foot = 62.4 pounds  
 1 cubic foot per second = 0.646 MGD  
 1 foot = 0.305 meters  
 1 foot of water = 0.433 psi  
 1 gallon = 3.79 liters  
 1 gallon = 8.34 pounds  
 1 grain per gallon = 17.1 mg/L  
 1 horsepower = 0.746 kW or 746 watts or 33,000 ft. lbs./min.  
 1 mile = 5,280 feet  
 1 million gallons per day = 694 gallons per minute  
 1 million gallons per day = 1.55 cubic feet per second (cfs)  
 1 pound = 0.454 kilograms  
 1 pound per square inch = 2.31 feet of water  
 1% = 10,000 mg/L  
 Π or pi = 3.14

---

**Abbreviations:**

cfs      cubic feet per second  
DO      dissolved oxygen  
ft      feet  
g      grams  
gpd      gallons per day  
gpg      grains per gallon  
gpm      gallons per minute  
in      inches  
kW      kilowatt  
lbs      pounds  
mg/L      milligrams per liter

MGD      million gallons per day  
mL      milliliter  
ppb      parts per billion  
ppm      parts per million  
psi      pounds per square inch  
Q      flow  
SS      suspended solids  
TTHM      Total trihalomethanes  
TOC      total organic carbon  
TSS      total suspended solids  
VS      volatile solids